27th of Jun

Husband ... will never meet,
Again and again you will try:
Come, enjoy, O Dear Brother,
For your sake, ...

S.N.P Mr Mr

mixed book. Nice.

Nice Book

How cruel are

LIFE IN NATURE

1. A help to Philosophy:—
Affon G

A

JAMES HINTON

LIFE IN NATURE

Edited with an Introduction

by

HAVELOCK ELLIS

LONDON

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INTRODUCTION

I

MANY of us never feel happy until we have acquired a sort of home-feeling in the universe. Of course there are a large number of people of whom this is not true. They are born to consume the fruits of the earth. They find it sometimes a troublesome enough task to obtain those fruits. Most of the time that is left over they spend in bringing up a progeny to carry on the process of consumption, and they do not much trouble about the "universe," whatever it may be.

That is a fundamental fact that must be accepted at the outset. It must even be added that among the people who consider themselves born for more than to eat the fruits of the earth and to return to it a corresponding amount of manure, the desire for a home-feeling in the universe may not be keen. They realise that what we call "life" is such a minute incident in the history of our own earth, only occurring after millions of years, perhaps by some most exceptional accident which has never taken place in

any other world and may never occur again in our own, that its origin is not worth troubling about. It is so remote, so obscure, as to be practically unknowable; we must be content to leave it as such, avoid speculations about the universe, and concentrate our intellectual energies on the scientific investigation of those actual phenomena which, in some sense or another, we really are able to know. They are content to be, as it has been termed, "crumbs of stellar dust." This is an entirely legitimate attitude, that well suits many persons of a type of mind which we may frequently regard not only with respect but with admiration.

There still remain a great number of people who crave to obtain some idea of that vast world in which they are such minute specks, and whose impulse it is to make a picture of that unknown or unknowable world, a picture which may be an artistic creation, yet may make it a possible home. All religions are the outcome of that craving, and religions, for perhaps as far back as the Mousterian period, if not earlier, have everywhere been found among men. My own opinion is that this general prevalence of religions by no means involves a special prevalence of religious people. Probably religious people were

never at any period more common than they are now; they may even have been less common. Yet they have always and everywhere been accepted by the majority of their fellows; they have given the tone to the social group in which they lived; their attitude and their ideas came to be regarded as those of the whole community.

There is no contemporary social group which we can properly call "primitive," the lapse of time since Man appeared is too great and communities are always changing. But when the material culture still approximates to what we may fairly consider primitive it is reasonable to suppose that there may be some approximation on the spiritual side also. That may lead us to view with interest such a people as the Arunta of Central Australia who have always been removed from the stream of civilisation and are still in the Stone Age. They have been so thoroughly and so elaborately studied by Sir Baldwin Spencer and F. J. Gillen that we know much concerning the relationship of man to the universe which their metaphysicians have worked out and spread abroad among them. The Arunta dwell in a land which is in the highest degree dry and barren, where life is precarious even for a savage and impos-

sible for a civilised man, a land that might be considered peculiarly favourable for a pessimistic attitude. But among these people, who are still primitive enough not to have differentiated science, religion, and philosophy, a conception of the relation of man to the universe has been evolved which argues a free and happy state of the soul, and renders possible a cheerful attitude towards life. Their metaphysical system is so subtle and penetrating that it has been said that no Platonic myth could more convincingly render that interplay of universal and particular, of identity and difference, which causes a thinking man everywhere to realise that, though he owns his individual soul, it in turn owns him by being in touch with something larger and more abiding. Even in a religion so remote from us, and among a people so much nearer to the early world, it is thus possible for the soul to seek and to find a home in the universe.

The spiritual phase of the recent centuries in Europe out of which we ourselves sprang is still familiar to us. Some might even say it is too familiar. The population of Europe has a strong poetic impulse and only a feeble metaphysical impulse, so it is not surprising that the prevailing religious con-

ception of what in old days was called Christendom has been highly concrete, thrown into a dramatic and picturesque form much less subtle—hard though that may be for us to believe—than the more abstract conception of the Arunta, and even less consonant with science, for the Arunta have a roughly evolutionary conception of Nature. The more personal and histrionic conception of Christendom had the advantage that at one extreme it lent itself to the highest flights of art, and at the other was comprehensible, with an effort, by the most humbly plebeian minds. It may be said to have been best presented, from the standpoint of art, by Dante on the Catholic side and by Milton on the Protestant side. At the other extreme it was set forth, in varying shapes which need not be characterised, from the altars and the pulpits of innumerable churches and chapels. Its merit was that, like the schemes devised in other parts of the world, it really symbolised the relation of man to the universe: it represented man as separated from the universe by his own deliberate act of rebellion, and showed how, in a kind of high comedy, or tragicomedy, by a series of dramatic events, he could be conceived of as being brought back into harmony

with the universe. But on the other hand, it had a serious demerit. It claimed a natural basis and yet was peculiarly difficult to bring into accord with any but a most primitive notion of Nature. It was essentially fitted for a flat stationary earth with what the modern aviator might call a "ceiling." This notion was superseded at the Renaissance, if not before, though it persisted in art. Even Milton, it is highly probable, who had known Galileo, accepted the old picture of the universe simply because it was suited to the ends of his art, himself only attaching a symbolical truth to it. After that it became unsuited even for symbolic use, except among the humbler practitioners of art who worked by routine.

By the nineteenth century not only had the old dramatic vision of the universe faded out, but the new and vigorous developments of science were making it increasingly difficult to replace the old vision. New physical properties were being discovered, and new laws that these properties obeyed; the world became mechanical and the energy it displayed was of an engineering sort, all hard, cold, and inflexible. Moreover, to those who had been brought up in familiarity with the beautiful religious legends

of old, it was all ugly and unlovely, with nothing to which the emotions could cling, so that though on one psychic side all that could be desired was there, the other side of the soul craved for satisfaction in vain. For while a Pygmalion may be drawn to a statue, if it is beautiful, we hear of no Pygmalions who have fallen in love with mechanical looms even of their own devising. But with the old vision gone, the universe seemed to many only a factory with a deafening whirl of machinery through which those who desired to find in it a home wandered disconsolately. I was myself in early life one of these. It was while in that mood, and when still in my teens (as I have told in a chapter of *The Dance of Life*), that I chanced to come upon James Hinton's *Life in Nature.*

II

James Hinton, born in 1822, was the son of a prominent Baptist minister in London, a remarkable man in his time, and partly descended from the Taylors of Ongar, a family possessing a rare degree of intellectual vigour and individuality. James Hinton himself manifested all the intense physical and

spiritual vigour and independence of his family. He entered the medical profession, became interested in the ear, and before long was the leading aural surgeon in London, with a large practice, while at the same time he published important works in connection with his specialty. He was sufficiently successful to be able to retire from his profession at the age of fifty. But he died not long after, in 1875, rather suddenly, apparently at the summit of his intellectual brilliance but in reality, it would seem, exhausted by his intense and restless energy.

Hinton's professional career is the least interesting aspect of his activity today, but it had its significance. He was a philosopher more than a scientist, yet he had a keen vision in science; he was, as his close friend Sir William Gull, the eminent physician, said, fully abreast of the most advanced science of his time; indeed, as we look back today, he sometimes seems ahead of it. It is his speculations in philosophy—and later also in morals though with these we are not here concerned—which now possess wider interest, and we have to bear in mind that these not only arise on a scientific basis, but are throughout guided by a mind which was familiar with biological laws.

Even today there are still to be found among us "vitalists" who believe that the phenomena of life are somehow outside the ordinary field of natural happenings, thus drawing a sharp distinction between Nature and life, and shutting up life in an unwholesome separate compartment away from the free air of Nature. It seems an uncomfortable doctrine. Anyhow, Hinton would have none of it. Indeed, he was far too much of a poet to accept so deadening a conception of life. "My affinities," he once wrote in a private letter, "are all with the poets, and my faculty is imagination." That is an essential fact of Hinton's temperament which we must bear in mind when reading *Life in Nature.* But we must also remember that he was not the poet of decorative verbal prettiness, but in a more substantial sense; it was with the naked wand of imagination that he struck the rock of Nature and the refreshing water gushed forth. Such imagination is one with scientific vision.

"Organic life is not a new thing in Nature," Hinton wrote to Croom Robertson in 1855; "there is *nothing more* in the organic than in the inorganic. All the inorganic—*all Nature*—is living." If we fancy that matter is "dead," he argued, our vision

is false, and the "deadness" is in us. To recognise that Nature is the reality of the spiritual world—of which our little conventional "spiritual world" is merely a fictitious image—thus becomes a joyful resurrection from the dead. That is the core of *Life in Nature*. Hinton thus preceded by more than twenty years the statement reached by the genius of Clifford that "along with every motion of matter there is some fact which corresponds with the mental fact in ourselves." The world which had seemed "material" becomes a "spiritual" world. "This is the conscious Being that I call Nature," wrote Hinton in the same letter, "the Being whose action has necessity, whose necessity is active, whose law is freedom, and with whom man will be one when his law is freedom too."

Hinton was sometimes carried away by the magnificence of the spectacle, alike in his letters and his private manuscripts. He felt, as he put it once, that he had been enabled "to rest upon the heart and clasp the very living soul of God." "Earth," he exclaimed again, "is infinitely better than any Heaven we can think." And again: "The Universe is a scene of absolute life and beauty and good; nothing is

there that is not so"—except, as he would add, that some refuse to share in it.

But we always have to remember that his outbursts of emotional exuberance spring from hard scientific thinking, aided, as indeed all sound scientific thinking must be aided, by a keen imaginative vision. "The vital force and the centrifugal force are analogous, or so much so that the same formula (almost) may be used for the expression of both, and the more simple used most instructively to illustrate the more complex": so he wrote (characteristically it was in a love-letter to his future wife) as early as 1851, and with hesitation, for he realised he knew too little of mathematics and astronomy. The molecular movements of chemical affinity, Hinton argued, are of the same nature as the movements of the heavenly bodies, and both of the same nature as the whole living body, movements of approximation combined with movements of divergence. "The motion of the double stars is the idea of life enacted on a different scale, atoms or stars endowed with approximating tendencies, yet carried perpetually into divergent relations by the centrifugal force." The vital force is another form of the physical force of

the cosmos. Today, with our new conception of electrons and protons, that idea may seem on the way to become a truism. But Hinton as a young man under thirty was feeling his path towards it eighty years ago. He was already on the road towards that conception of the "mystery of life" which he was later to embody in *Life in Nature.*

III

"Whatever else he can do, this man can write!" Such was the exclamation of Thackeray, the famous novelist who at that time edited the *Cornhill Magazine,* when he accepted for publication *Life in Nature,* in its serial form entitled "Physiological Riddles." Hinton's qualities as both thinker and writer had, indeed, been appreciated from the first, and his earliest book, *Man and his Dwelling Place,* published anonymously, was attributed in turn to some of the foremost thinkers and writers of that day. The writer in Hinton was, however, secondary to the thinker; it was the vigour and passion of his thought which made him a writer. He was interested in thinking; he was not really interested in writing. "I do love thinking," he wrote once in a

letter, "it is the most beautiful and enchanting of all arts." It was, indeed, his love of thinking, rather than the pressure of professional work, which prevented him from writing many books. His active pen, it is true, followed his intensely active mind and scribbled down reams of thinking, but he failed to work it up into coherent wholes. Thus it is that *Life in Nature* remains probably the best piece of connected writing he ever produced.

What, reduced to its simplest terms, is the argument of this book? We may best understand it by starting from that doctrine of "materialism" which so upset the ordinary man in the nineteenth century, and is still disturbing to many even today when the conception of "matter" has been revolutionised. To apply a "materialistic" explanation to life seemed to deprive it of its glory, to kill what had been its special "spiritual" exaltation, to reduce it to the low and commonplace level which (except for poets at moments of unusual extravagance) characterised everything in nature outside life. It was all very depressing.

Up to this situation comes Hinton, a man of poetic imagination, indeed, but at the same time a man of science and a man of religion. The situation

was at once in his hands transformed, even reversed. "You are faced," he said to the depressed victim of "materialistic" science, "by a small ingot you believe to be gold and a large mass you believe to be clay, and you are told they are both of the same nature. You jump to the conclusion that they are both clay. *But what I can prove to you is that they are both gold!*" The parable is Hinton's own. It is the core of his *Life in Nature.*

Life, as Hinton views it, is the revelation of Nature. It is "the bright blossom wherein Nature's hidden force comes forth to display itself, the necessary outpouring of the universal life that circulates within her veins unseen." The stream that has run darkling underground, he declares, here bursts forth to sparkle in the sun.

Thus the key to this conception of our universe —and it is a key which science is ever learning better to use—is the fundamental unity of the world, not in the sense of debasing the organic to the level of the inorganic, but rather of raising the inorganic to the level of the organic, regarding them as two aspects of the same unity, each to be interpreted by the help of the other. The "vitalists" would persuade themselves that life is a little enclosed cyst in

the world, impenetrable to the laws of Nature. It is the distinction of Hinton that even seventy years ago he showed how feeble and futile is that conception. Indeed one may well doubt if anyone since has, with so fine a blending of scientific insight and poetic fervour, set forth the doctrine of today concerning the place in Nature of life. Our knowledge is growing; the organic "atom" of today is not what it was in Hinton's days, nor our conception of the organic "cell"; they are both incomparably more complex. But the fundamental doctrine as stated by Hinton thereby becomes clearer; where Hinton foresaw, we see. And the notable point is that he foresaw with so splendid a glow of joy in the vision before him. He admitted that he was putting forward what was still a "doubtful suggestion," but he was confident that it would soon become "the legitimate fruit of time."

There is much, no doubt, in this mid-nineteenth century book, which may not be read sympathetically even by those who enjoy the clear and eloquent presentation of its central core. That is my own case. The "deadness" in Man which Hinton likes to dwell on as standing in the way of a general glad acceptance of the reality of life in Nature seems

to me unnecessary, and even to be a relic of old theological ideas. It is as though he assumed a sort of "Fall of Man" which impeded our reception of this glad news of salvation.

It must indeed be admitted that the traces of old theological doctrines, derived from Hinton's early upbringing on the Bible, constantly slip into this book. Hinton even welcomed them and liked to dwell on them; he never definitely broke with his early faith, and never seems to have realised how little connection his own fundamental conceptions possessed with that faith. Here, and even more in the early manuscript material he left behind, he lavishly pours his new wine into bottles nearly two thousand years old.

That, it must also be admitted, will be counted to him for righteousness by those who are well pleased to find that the modern doctrine put forward in this book may yet be harmonised with the religious faith of their own childhood. I see no reason for disturbing that, for many no doubt, comfortable belief.

I must, however, at the same time point out that in Hinton's creative imagination that early faith is singularly transformed. I do not myself at all see

the old bottles safely holding the new wine. His "theology," whatever he may himself have thought, is far from being the Christian theology. The God enthroned in his Heaven is as unlike as possible to the fierce Jehovah of the Hebrews. It was much more like his conception of Man. "I have not reasoned out," he wrote to a friend, "the being I mean as Man; I perceive, nay I love him, that is *Her*, for she is by no means a colossal man, but a little trembling, quivering, passion-driven woman, throbbing with uncomprehended instincts, and afraid with timid regrets and sorrows for half-imaginary sins, which she repents of but knows she will still commit. I don't know about any 'colossal' thing whatever, but that little restless woman thing I know, for she works in me and keeps me in perpetual unrest." And since Hinton had the most vivid and penetrating sense of the oneness of Man and Nature, and the identity of the laws manifested in both, no violation of his thought is involved in transferring that "little restless woman thing" into the metaphysical sphere.

To me, however, the easy nonchalance with which Hinton uses the traditional doctrines of Christianity was rather irritating when I first en-

countered it, and though I now view it with a smile, I suppose it will be disturbing to many readers still. We do not, indeed, here find such fantastic interpretations of Christian symbols as sometimes occur in Hinton's early manuscripts. But he still persists in speaking of Man's "deadness," an expression without exact meaning, either scientific or psychological. Here again, however, it is merely a matter of expression, and Hinton declared that he was quite willing to give up the phrase, "deadness in man," provided that it was agreed that "Nature is truly active and that a want in man makes him feel it inert." Such "deadness" is simply that state of all of us in the presence of discoveries we have not yet made. Similarly Hinton explained that by "God's law" he meant Nature's—"Nature whom I have known so long, and half loved, and half feared, and wholly served."

IV

"I know I am unimaginably remote from present ways of thinking," said Hinton. "Nor do I expect acceptance except from a certain class of minds; but there are altogether a good many of that class."

And he adds that they were often men of vigorous and practical minds.

Life in Nature, it is true, attracted a certain amount of attention when it appeared in the *Cornhill*, and when published as a volume it went into a second edition. But it was too far aside from the currents of thought of the day to be received with genuine appreciation. Today conditions have changed. And just as Hinton's pioneering views on sex morality, which seemed so shocking in his own day that they were never published, no longer seem outrageous because we are alive to the reality of sex problems, so it may well be that Hinton's vision of the universe may have a new meaning, even for those who regard it as in form out of date. Indeed, now that the constitution of the universe under scientific analysis and theory begins to reveal aspects so different in shape and substance from that which it wore in Hinton's day, it may well prove the more apt to lend itself to a vision such as Hinton's.

The French critic Benjamin Crémieux has lately referred to the significant progress made, ever since the Great War, in enlarging the traditional classic notions of man by explorations on all sides

into the hitherto unconscious and unknown, the varieties of human temperament, the nature of the alleged "supernatural" phenomena, the soul of the savage, the life and mind of animals, and, yet more daringly, of plants; even further, the attempts alike of poets and scientists towards a new cosmic intimacy with the world beyond the conventional spheres of "life."

The inevitable result is dissatisfaction with the old religious faiths and a remoulding in various directions of the religious attitude. This movement is not confined to any one of the traditional creeds or to the men of any one nation. If, for instance, we turn to Catalan Spain we find Coromines in his *Vida Austera* expressing the feelings of many in widely remote lands. He speaks not only for himself but for other men of religious temperament who have lost their early dogmatic faith under the criticism of science when he points out that the problem presented in the actual phase of Western civilization is to realise that the old dogmas failed simply because of their inferiority, as demonstrated by their inability to withstand criticism, and that it is not a feeble substitute for religion that we now need, but a faith

resting on no mere historical foundation, a religion larger and more satisfying than that which has passed away. That is to say, that when traditions have lost their force, the way has been opened for a more confident conception of the universe as a home for the soul. Every affirmation of the spirit was young once, and sprang alive from a human consciousness. Scientific criticism is vain unless it teaches us that the traditions of the past have no more value—however sacred we may justly count them—than the traditions we make today.

We are in fact making traditions. Thus even before Bergson, as Ramon Fernandez considers, Paulhan put forward the revolutionary conception of new psychological theories of consciousness, by substituting, for a static atomism, a dynamic activity *sui generis* of consciousness. Hinton, too, was doing this with his dynamic conception of activity in Nature, moving in the direction of least resistance, and indeed, as we read much of what he wrote in the middle of the last century, we realise how he was feeling forward toward our attitude today, where in a world re-oriented by Einstein, men of scientific training and distinction like Jeans and Eddington

and Whitehead are putting forth conceptions which Hinton would have greeted with joy as those of which he had prevision.

Thus we find Eddington (as in his *Science and the Unseen World*) pointing out how the old "materialistic" conception of science has by science been transformed into symbols, the nature of what the symbols stand for being unknown. We only know the equations which they obey; "matter" has been reduced to a symbolism, no longer in conflict with what we call "spirit"; and both are equally far from what we used to call the "concrete." The world remains as "real" as ever, but the old ideas of its "substantiality," and of its division into "material" and "spiritual" no longer have the old clear-cut precision. The religious seeker who pursues significance and values need no longer be unfavourably compared with the scientist who pursues atoms and electrons. Provided, also, that he does no violence to his scientific attitude nor bases his religion upon his science, he is justified in allowing his emotions to play a part in constituting his religious attitude and establishing a personal relationship to the universe, whether or not he uses the symbolic name of "God."

"God" is always a dangerous name to use, for it lends itself to so many interpretations, sometimes at the hands of the same person, even one so scientifically and philosophically competent as Whitehead, whom we find, in his Lowell Lectures on *Religion in the Making*, throwing out perpetual new definitions of "God" in the easiest and most copious manner: "the completed ideal harmony," "that element in life in virtue of which judgment stretches beyond facts of existence to values of existence," "the measure of the æsthetic consistency of the world," and so on in confusing fertility.

Eddington, representing the scientific man of today who admits a religious attitude, seems in some respects less modern than Hinton, who, in essentials, makes fewer concessions to traditional religion and sets less narrow limits to the scientific domain. We may find the scientific attitude of today, in its open side towards the possibilities of religion, perhaps even better presented in Jeans, because with less tenderness towards tradition, than in Eddington, who associates himself more or less with Quakerism, which, while it may be called creedless, is still traditional. Jeans' attitude—though he starts from

mathematics and not from biology—is definitely nearer to Hinton's, and not only in attitude but sometimes even in statement.

"The old dualism of mind and matter," he declares in *The Mysterious Universe*, "seems likely to disappear." That disappearance was what Hinton was fighting for before Jeans was born. Like Hinton, of whom he may never have heard, he believes that the activities of life are akin to the activities of Nature; "we are not so much strangers or intruders in the universe as we at first thought." Jeans rejects the mechanical physics commonly held in the last century as "conspicuously inadequate." According to the narrow mechanical theory into which Helmholtz and Kelvin—obeying, indeed, what was in their time a sound and helpful impulse—would have squeezed all Nature, "our tiny corner of this universe of atoms had chanced to become conscious for a time, but was destined in the end, under the action of blind mechanical forces, to be frozen out and again become a lifeless world." We now realise that "Nature seems very conversant with the rules of pure mathematics," and those rules are *our* rules, the creations of our own thought. So that there is not only our life in Nature, but our thought.

Thus Jeans today regards a mechanical attitude as typical of nineteenth-century science. Yet Hinton even more than fifty years earlier—evidently a pioneer here also—declared (*Contemporary Review*, 1874, a year before his death) that "science absolutely refuses mechanicalness in Nature: matter and force are only used as x and y are used by the mathematicians." The laws of Nature, Jeans remarks, are comparable to those a musician obeys in writing a fugue, or a poet in composing a sonnet. "The motions of electrons and atoms do not resemble those of the parts of a locomotive so much as those of the dancers in a cotillon." One can imagine Hinton clapping his hands in glee, as he was wont to do when a new congenial idea swam into his ken. Life and thought are no accident in the universe, they are of its essence. The well-known French astronomer, Antoniadi, who has specially studied Mars, thinks it "not at all impossible" that there may be not only vegetable but even animal life on that planet. This is speculation, but the way has now been opened to such speculation.

The mathematical modes remain symbols. The mathematical pictures that science draws are still pictures, fictions if we will, in that sense of Vai-

hinger's "as if," by which fiction is the best way of enabling us to grasp reality. Eddington would be willing to regard time as typical of the kind of stuff of which we may imagine the world to be made. Some deny, and others accept, the existence of an æther, but it is only a difference about words, for those who accept and those who deny both mean the same, and Lodge, who accepts the term, would be willing to replace it by the term space. The universe, as Jeans puts it, is a corrugated soap-bubble blown out in emptiness. The emptiness is the important thing about it, and Lao-tse, the earliest of the religious mystics and still one of the greatest, when he said in China twenty five centuries ago, that it is in the emptiness of things that their value lies, as symbolised by windows and by vessels, was anticipating the standpoint of modern science.

Eddington and Jeans, indeed Hinton also, approach the problem from the side of science. That is why their witness counts for much when they tell us that, from the scientific outlook of today, the way is open for a religious vision of the universe and even that science now aids such a vision. Imagination and emotion must be combined with science, said Hinton, to obtain an adequate vision of the

universe. But for a comprehensive and balanced picture of the relations of science and religion we must invoke philosophy, free to follow both paths and yet bound to neither.

Among thinkers of this sort, at once living and recent, I am accustomed to turn to Jules de Gaultier, and I do so the more readily since in recent years he has clearly put forth his statement of this problem, notably in an essay on "*The Limits of Intelligence and Faith*" (published in English in the *New Adelphi* for December 1927). Gaultier here recognises two activities of the human spirit: one according to the *principle of relativity*, which is strictly intellectual, reasonable, and logical, dependent upon experience, evolving and struggling, moving forward in the field of social morality, seeking for reform and for betterment in an often evil world. On the other hand are the activities that come of the attitude of *faith*, or rather of *mysticism*, for the attitude to be understood here is deeper than that which rests on the credulous acceptance of an unproved and unprovable creed, which should properly indeed be submitted to the test of relativity. Here is a domain beyond the limits of relativity which in its own field only admits

existence as divided between subject and object. But religion in its mystic form is the union of desire with the object of desire; and this the principle of relativity has no authority either to affirm or to deny. In the sphere of relativity there is unappeasable discontent, the mainspring and creator of moralities, sciences, and the religious systems of the crowd. But there is nothing the mystic desires to change; he sees existence as perfection, *sub specie perfectionis*, as Spinoza phrased it. For many, even within the boundaries of Christian Churches—and not of such Churches alone—this attitude is attained by religious contemplation, when the mystic feels that he "sees God." Gaultier would attain it by æsthetic contemplation: the vision of a world in which the spectator has brought about the metamorphosis (as the devout Catholic that of bread and wine into divine flesh and blood) of joy and sorrow into the single experience of beauty.

The problem need no further be pursued. We have reached the sphere in which Hinton moves in his *Life in Nature*, the sphere in which the men of many climes have moved at rare moments of spiritual exaltation or even habitually. Today, Lewis Browne has lucidly set forth in his "interpreta-

tion of Christian history," *Since Calvary*, the modern plight over religion. The crowd has become split into two sections: on the one hand those, still anxious to clutch something of the old faith, who become fanatical obscurantists, "Fundamentalists," as they are called if Protestant and "Reactionaries," if Catholic; on the other hand those who, contentedly or discontentedly, drift at random. So that today religion among the crowd is on the one side degraded, and on the other side has no existence at all.

Yet, we see, outside the region of "relativity," a recognisably legitimate road still open to such as desire to seek it. Certainly, for those who are sensitively alive to the equally valid claims of relativity that road can only be sought individually. "Religion," as Whitehead well says, "is what the individual does with his solitariness." That "solitariness" is fundamental—"the Kingdom of Heaven is within you"—and it is in its decay that religion sinks into sociability. The crowd, able to distinguish categories only vaguely if at all, will be content, when it feels the need of religion, to take it mixed with a creed in the social sphere that is properly that of relativity. The few who are acutely conscious of the

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legitimate claim on the whole man of the two opposite paths must find the mystic's way for themselves, or wait patiently till the vision of it is revealed.

Of these was Hinton as shown in this book of *Life in Nature*. His is not the only way, but one among many, and to some it may need modification, for in no two generations are even the finest spirits oriented towards exactly the same quarter.

Yet at all events—whether or not fit for many to climb—here is one of the ladders which daring and imaginative men have set up on earth to reach that home of the soul which is sometimes called Heaven.

HAVELOCK ELLIS

August

[illegible]

This pen belongs to
[illegible] Mahi Raaj ?
S.S.C. Student
S.P. College
Srinagar, Kashmir

Enquiry Commission [illegible] your house immediately.

No ink in my fountain.

PREFACE

TO

THE SECOND EDITION

I AM AFRAID it is not probable that many people will like the whole of this little book. Those who approve the first part will most likely wonder how I came to write the second; and those who find the second to their taste will very likely feel an antagonism to the first. They are indeed very opposite: the first part tries to resolve Life into mechanism, and the second tries to prove that mechanism is Life.

It must seem to many a foolish toil. But all I can say is that I believe both arguments; and that to me they seem to make a consistent whole; a whole which it is joyful to think true.

In a book written twelve years ago there can hardly be expected much that is new. And, indeed, the less there is of new in it, the better pleased the writer might reasonably be. The ideas it embodies were floating about the world—by no means any one's private property—when first it was written.

And how mere a straw upon a current it was, appears to be shown by the much wider prevalence and more decided expression, in the present day, of views more or less parallel to those which it contains. I have argued here that Life is a universal character in Nature; that Nature (using that term for the cause of our experience, the fact or existence that surrounds us and acts on us) is a conscious existence, and not merely unconscious as it seems; but that this seeming unconsciousness is due only to an inadequacy in our impressions. Now assuredly these are no longer any strange or very unusual thoughts. I do not mean that, as I individually present them, they are widely spread; but that in respect to the general thought—of Nature as presenting a universal Life, and as consisting, truly, of elements that include some form or mode (even if it be only the germ) of consciousness—there are distinct signs of a growing consensus of thoughtful men.[1] In fact, the feeling that our apprehensions of Nature are partial and inadequate (so that the ideas we form of the world around us are but phenomenal, and cer-

[1] See, for example, Mr. J. Allanson Picton's "Mystery of Matter;" and a Paper by Professor Clifford on "Body and Mind," in the *Fortnightly* for December 1874, p. 732. And as evidence how far this thought is from being connected with any special form of opinion, I may refer to J. H. Newman's "Apologia," p. 90.

tainly fall short of the truth), as it becomes more familiar, naturally begins to germinate in the mind and bring forth results. One of these results being, of course, that men begin to ask: If the Nature that science teaches of is but an appearance, of what is it likely to be the appearance? And this enquiry, I venture to think, will not be so futile as we have been sometimes warned it must be. Man has had much experience in finding out the meaning of appearances; and has learnt some useful facts to guide him: not the least useful of these facts being that he is prone to be too quick in his conclusions; and that things may seem very certain to him which are not true. Now, how should we know whether an appearance can be interpreted into that which causes it to appear until we have tried? And have men yet tried to interpret thus the appearance that we call Nature? I venture to think they have not. True, they have long tried, and have failed, to do something else, namelv, to find out some absolute existence *in* the appearance itself. But in this, of course, they were sure to fail: the thought was a mistaken one. An appearance, or phenomenon, being but apparent, can have no existence in it but an apparent one.

What we have learnt by these centuries of trying

is to ask the right question; which Lord Bacon called the half of knowing. We have learnt to recognize that there is some deeper truth implied by our experience, so that we are prepared to use its results as stepping-stones to farther enquiry. We have learnt not to rest, as we were wont to do, in our mere impressions, however accurately formulated; so that the material world no longer stands as the true cause of our perception. We have recognized that our experience is due to some other source than that.

Here, therefore, is our question: What is that Existence, Being, Power, Fact—however we may like to call it—which so acts on us as to cause us to perceive the material world? Is this a question which has been exhausted yet?

Are we sure even that we have yet gained the right method of attempting it? May we not be pronouncing the task impossible, when we should rather be turning our criticism to our own mode of proceeding? I have ventured here to suggest, and to try, some different plans: especially to urge that the emotions are rightly entitled to a place in this enquiry which has not yet been given them.

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... all your loved nearly ... remembered
Earth shall quicken & the ... trees sigh.
A touch of June shall tremble old November
as though you had passed by.
you = 751. / yr 1946.

INTRODUCTION

THE following pages contain a popular exposition of some of the most interesting questions which Living Bodies suggest, and are designed to present in a brief compass and easily-intelligible form a general view of them, which, it is believed, will be found more simple and more satisfactory than the ideas commonly entertained. All thoughtful persons feel that the subject of Life cannot be satisfactorily discussed on physiological grounds alone, but that it opens up some of the deepest problems which surround our existence, and raises questions the practical importance of which cannot be overestimated. I have therefore endeavoured to give a brief expression to the views which I entertain on some of these questions; feeling that science, happily for us, cannot, even if she would, confine herself to the mere relations of physical objects or material forces; but that she has a message for us, not less from heaven because conveyed through earthly instruments, respecting our inmost nature and our highest rela-

tions. Science, in a word, can teach us—it is her loftiest function and her greatest boon—not only respecting nature, but respecting ourselves, and so can enable us to look with purged eyes on objects which only to our blinded senses can seem trivial. We lose our privilege, we fall short of our duty, if we do not seek to gather these fruits wherever they are presented to our hand.

In perusing these pages, the reader, especially if unaccustomed to similar studies, will possibly experience more or less of a feeling as if he were losing hold of something that he could not afford to part with. He may feel that there is a tendency in them to materialize that which he cannot but regard as altogether above matter, and to reduce to the level of mechanism that which owes its chief beauty to its freedom from mechanical conditions. If so, let him by all means cherish this feeling. He could by no possibility more entirely depart from the spirit of the book than by seeking to suppress it, or in any way to diminish its force. No one more firmly or more reverently than myself believes in the authority of feelings of this character; it is chiefly because I believe also that they can receive their perfect satisfaction only through modes of thinking such as are

here set forth, that I attach any value to the thoughts. But in truth the course through which I solicit the reader to follow me is of a twofold character. I beg a relinquishment in order to a fuller possession; a giving up as the condition of a more abundant having.

Let it be supposed that there stood before us two bodies, one a small ingot of gold, the other a mass of apparent clay; and that a man should set about to prove to us that the small ingot was really of the same kind as the larger mass. Supposing now the former were truly gold, what would he thereby prove but that the larger mass, though seeming otherwise, was truly also gold? Yet it might seem to us, confident in our impressions, that he was taking the opposite course and trying to reduce gold to clay; and we might for the sake of retaining the less, be impatient of the very proofs which would establish the presence of the more.

It is just in this way we feel when we are reluctant to admit evidence which tends to demonstrate an identity between the organic world (that is, of plants and animals) and the rest of nature. When arguments of this kind are suspected of a tendency to banish life from the world and interfere with the

Creator's prerogative, it is surely forgotten that those forces and laws to which the phenomena of vitality are thus referred, are to be judged of by their fruits, and not to be pronounced beforehand incapable of bearing them. To assume that we know what those laws and forces are, and are capable of doing, is arbitrarily to limit our own capacities. If the organic and the inorganic worlds in nature are two presentations to us of one thing, how much more penetrating and worthy may our knowledge become of both, each being interpreted to us by the other!

Let it be assumed, for argument's sake, that all the phenomena of life could be traced back to chemical and mechanical powers, what would follow? Simply that all the wonder and admiration with which we now regard the living body, would be extended with increased intensity and elevation to those powers, which we call chemistry or mechanics, but which we should then perceive we had entirely under-estimated. Would it not be beautiful to see these forces stand before us thus in a new attitude and with more than doubled lustre; on the one hand confining themselves within the equable and unvarying sequence which the mechanist or

chemist seems to have entirely within his grasp, and on the other breaking forth, as if to mock man's fancied rule, into the infinite variety and spontaneous grace of life?—the very union of law and liberty, reminding us that liberty is truly none the less, is only, there where law is perfectly fulfilled; that in the perfectness of freedom the perfectness of obedience lies hidden, each in each, yet in Nature separately shown to us (else undiscerning) that we may learn to know them both. But on this point it is needless to say more here, since it is discussed in other parts of the volume.

In respect to the views herein contained, I have no wish to make any claim to originality. I believe that in this case as in so many others, similar ideas have occurred at about the same time to various persons, showing that a new line of thought is rather an expression of prevailing tendencies than the result of individual effort. I have sought to give a reference to every writer in whom I have met with a decided similarity to my own ideas, in so far as they differ from those ordinarily received; but in case I have failed in doing this, I wish to state expressly that in publishing them under my own name, I put in no claim to be anything more than their mouthpiece.

I have, however, placed at the end of the volume an essay written by me in the year 1855, and submitted at the time to some eminent scientific men, but not before published. It presents the first form in which the idea of Nutrition suggested itself to me.

JAMES HINTON.

LONDON: *November* 10, 1862.

CHAPTER I

HOW WE ACT.

The interest which attaches to the study of our bodily structure and powers is daily more widely felt, as the importance of the subject is more fully recognised, and especially as the relations which connect our bodily with our mental and moral life are better understood. Nor is this interest diminished by the difficulty with which its satisfaction is often attended. It is, indeed, stimulated rather than deadened by obstacles, and the desire to penetrate this mysterious world of material life, on which all that is best and highest in humanity rests as its foundation, is one that grows by disappointment. For the study of life is apt to end in a feeling of this kind. The multiplicity of the facts recorded by physiologists, the ingenuity of the experiments, the intricacy of the results—the astonishing amount of light, and the insuperable darkness—produce a mingled effect upon the mind. As observations multiply, doubts multiply with them. We are half disposed to ask whether we really know

anything on the subject. Is there anything certain in physiology at all, besides what we can see?

If there is, it must be by virtue of some fixed and certain principles; through the establishment of laws which can sustain the shock of apparent exceptions, and to which we may with confidence seek to reduce anomalies. No science has made real progress till it has passed out of this state. So long as no certain principles or necessary laws have been discovered in any branch of knowledge, we cannot tell what we may believe, and, at the best, its doctrines form a mass of truth and error inextricably mixed.

If, therefore, any relations in the vital processes could be ascertained, which must in the nature of things be true, like the propositions of geometry, or if any physiological laws could be found, based on a sufficiently wide induction to give them authority as standards, like the laws of gravitation in astronomy, or of definite proportions in chemistry, this would be a great aid both to the comprehension and to the advance of the science. And we may try whether, in this aspect, a clearer light cannot be thrown upon some of the points on which the main interest of physiology centres.

Too much must not be attempted at once. So, dismissing for the present all other subjects connected with the living body, we concentrate our attention on the question, Whence comes its active power? Taking the body as it stands, supposing it originated, developed, and nourished, by means which we do not now consider, we ask ourselves, Can we find the reason of its spontaneous activity?—why action should go on within it, and force be exerted by it on the world around?

There is a term we shall find it convenient to use in this inquiry, and may, therefore, briefly define. The actions of a living body are called its "functions." One of those functions is muscular motion, whether external or internal; another is the nervous action; and a third includes various processes of secretion. The growth and nourishment of the body we do not include among the "functions," as we propose to use the term.

We inquire, then, why the living body has in itself a power of acting, and is not like the inert masses of merely inorganic matter? And here let us first observe, that some other things besides the animal body possess an active power. "It died last night," exclaimed the Chinaman, in triumph, on

selling the first watch he had ever seen. And certainly a watch is like an animal in some respects. Under certain conditions, it has an active power as like that of the heart as could readily be devised. What are those conditions? They are very simple. It must contain a spring in a state of tension: that is, force must have been applied to it in such a way as to store up power, by opposing the tendency of the metal to straighten itself. Let us fix in our minds this conception of a tension, or balancing of two forces in the watch-spring. The power applied in winding it up is exerted in opposing the elasticity of the steel; it is compressed—coerced. The production of motion from it, when in this state, is a quite simple mechanical problem: let it unbend, and let wheels and levers be at hand to convey the force where it may be desired.

Let it be observed that the force thus exerted by the spring, and on which the "functions" of the watch depend, is truly the force that is applied by the hand in winding it up. That force is retained by the spring, as it were in a latent state, until it is applied to use: it exists in the spring, as tension—a state intermediate between the motion of the hand in bending it, and of the hands of the watch

in their revolutions. But the motion is the same throughout. It is interrupted and stored up in the spring; it is not altered. We may say that the tense spring is the unbent spring *plus motion*. It embodies the force we have exerted. It is not the same thing as it was in its relaxed state; it is more. And it can only pass again into the unbent state by giving out the force which has been thus put into it.

Steam is an instance of a similar thing. Water, in passing into vapour, absorbs or embodies no less than 960 degrees of heat. Vapour is not the same thing as water; it is more—it is water plus heat. Nor can it return into the state of water again, without giving out all this heat. Vapour, therefore, in respect to force, is like a bent spring, and water is like the spring relaxed.

And further, as a bent spring *tends* constantly to relax, and will relax as soon as it is permitted, or as soon as ever the force which keeps it bent is taken away, so does vapour constantly tend to return to the state of water. It seeks every opportunity, we might say, of doing so, and of giving out its force. Like the spring, it is endowed with a power of acting. Let but the temperature of the air be cooled, let a little electricity be abstracted from the

atmosphere, and the force-laden vapour *relaxes* into water, and descends in grateful showers.

In the vapour, heat opposes the force of cohesion. It is not hard to recognise a tension here; the heat being stored up in the vapour, not destroyed or lost, but only latent. And when the rain descends, all this heat is given off again, though perhaps not as heat. It may be changed in form, and appear as electricity for example, but it is the same force as the heat which changed the water into vapour at the first. Only its form is changed, or can be changed.

Now the living body is like vapour in this respect, that it embodies force. It has grown, directly or indirectly, by the light and heat of the sun, or other forces, and consists not of the material elements alone, but of these elements *plus force.* Like the vapour, too, or like the spring, it constantly tends to give off this force, and to *relax* into the inorganic form. It is continually decaying; some portion or other is at every moment decomposing, and approaching the inorganic state. And this it cannot do without producing some effect, the force it gives off must operate. What should this force do then? what should be its effects? What but the "functions"?

For the force stored up in the body, like all force, may exist in various forms. Motion, as the rudest nations know, produces heat, and heat continually produces motion. There is a ceaseless round of force-mutation throughout nature, each one generating, or changing into, the other. So the force which enters the plant as heat, or light, &c., and is stored up in its tissues, making them "organic" [1]—this force, transferred from the plant to the animal in digestion, is given out by its muscles in their decomposition, and produces motion: or by its nerves, and constitutes the nervous force.

In this there is nothing that is not according to known laws. The animal body, so far, answers exactly to a machine such as we ourselves construct. In various mechanical structures, adapted to work in certain ways, we accumulate, or store up, force: we render vapour tense in the steam-engine, we raise weights in the clock, we compress the atmosphere in the air-gun; and having done this, we know that there is a source of power within them from which the desired actions will ensue. The principle is the same in the animal functions: the source of power in the body is the storing up of force.

[1] As heat, we may say, makes water "gaseous."

But in what way is force stored up in the body? It is stored up by *resistance* to chemical affinity. It is a common observation, that life seems to suspend or alter the chemical laws and ordinary properties of bodies; and in one sense this is true, though false in another. Life does not suspend the chemical or any other laws; they are operative still, and evidence of their action is everywhere to be met with; but in living structures force is employed in opposing chemical affinity, so that the chemical changes which go on in them take place under peculiar conditions, and manifest, accordingly, peculiar characteristics. If I lift a heavy body, I employ my muscular force in opposing gravity, but the law of gravity is neither suspended nor altered thereby; or if I compress an elastic body, my force opposes elasticity, but the laws of elasticity are not thereby altered. In truth, the forces of gravity and elasticity thus receive scope to operate, and display their laws. Just so it is in the living body. The force of chemical affinity is opposed, and thereby has scope to act; its laws are not altered, but they operate under new conditions. Owing to the opposition to chemical affinity, the living tissues ever tend to

decompose; as a weight *that has been lifted* tends to fall.

But the living structures are not the only instances, in Nature, of bodies which tend to decompose. There are several in the inorganic world: such are the fulminating powders (iodide or chloride of nitrogen, for example,) which explode upon a touch. There is a strong analogy between these and the living tissues. In each case, there is a tendency to undergo chemical decomposition; in each case, this decomposition produces an enormous amount of force. Explosive powders may be compared to steam that has been heated under pressure, and which expands with violence when the pressure is removed. The tendencies of these bodies have been coerced by some force, which is thus latent in them, and is restored to the active state in their decomposition. This is the point of view from which the living body, in respect to its power of producing force should be regarded. The chemical tendencies have been resisted or coerced, and are, therefore, ready, on the slightest stimulus, to come into active operation. And the "functions" are effected by this operation of chemical force upon the various adapted

structures of the body. The animal is a divinely made machine, constructed, indeed, with a marvellous delicacy, perfection, and complexity; and depending upon a power, the vital modification of force, which it is beyond our skill to imitate, but still involving, in the laws of its activity, no other principles than those which we every day apply, and see to regulate the entire course of Nature.

We speak of "stimuli" to the vital functions—of the things which stimulate muscular contraction, or stimulate the nerves. What is the part performed by these? They are what the spark is to the explosion of gunpowder; or what the opening of the valve that permits the steam to pass into the cylinder, is to the motion of the steam-engine. They do not cause the action, but permit it. The cause of the muscular motion is the decomposition in the muscle, as the cause of the motion of the piston is the expansion of the steam; it is the relaxing of the tension. In the muscle, the chemical affinity on the one hand, and a force which we will call, provisionally, the vital force on the other, exist in equilibrium; the stimulus overthrows this equilibrium, and thus calls forth the inherent tendency

to change of state. Magnets lose for a time their magnetic property by being raised to a red heat; if, therefore, to a magnet holding a weight suspended, heat enough were applied, it would permit the fall of the weight. It is thus the stimulus "permits" the function.

So one of the most perplexing circumstances connected with the phenomena of life becomes less difficult to understand; namely, that the most various and even opposite agencies produce, and may be used by us to produce, the same effects upon the body. The application of cold, or heat, or friction, alike will excite respiration. Any mechanical or chemical irritation determines muscular contraction, or will occasion in the nerves of special sense their own peculiar sensations. These various agencies operate, not by their own peculiar qualities, but by disturbing an equilibrium, so that the same effect is brought about in many ways. A sudden change is the essential requisite. As almost any force will cause a delicately-balanced body to fall, so almost any change in the conditions of a living body, if it be not fatal to its life, will bring its functional activity into play. Anything that in-

creases the power of the chemical tendencies, or diminishes the resistance to them, may have the same effect.

To recapitulate: Chemical affinity is opposed, and delicately balanced, by other force in the organic body (as we oppose forces in a machine; the elasticity of heated steam by the tenacity of iron for example); and this affinity coming into play—spontaneously or through the effect of stimuli which disturb the equilibrium—is the secret of the animal functions. The body is not in this respect peculiar, but is conformable to all that we best know and most easily understand. The same principles are acted upon by every boy who makes a bird-trap with tiles and a few pieces of stick; here is the opposition to gravity, the equilibrium of force and resistance, and the unfortunate bird applies the stimulus.

But if the case be so simple, why has it not always been presented so? Why has it been conceived that the living body had an inherent activity peculiar to itself? And why especially has the decomposition of the body been represented as the result, and not as the cause, of its activity? Many circumstances have contributed to make this prob-

lem difficult of solution. In the first place, if the animal is like a machine in some respects, in others it is strikingly unlike one. All machines consist of two distinct parts: the mechanism and the power. First, men construct the boiler, the cylinder, the levers, the wheels, all the parts and members of the steam-engine, and then they add the water and the fire—first, they arrange the wheels, the balances, the adjustments of the watch, and then they bend the spring. In the body these two elements are united, and blended into one. The structure itself is the seat of the power. The very muscles that contract, decompose; the brain and nerves themselves, in their decay, originate the nervous force. It is as if the wheels of the steam-engine were made of coal, and revolved by their own combustion; [1] or as if the watch-spring, as it expanded, pointed to the hour. Here is a broad distinction between all contrivances of ours and living organisms, and this made it the harder to perceive the essential correspondence. For the burning of the coal (an organic substance) to move an iron wheel, differs only in detail, and not in essence, from the decomposition of a muscle to ef-

[1] The catharine-wheel is an instance of this very thing: structure and power united. But the firework is not renewed as it decomposes; the "nutrition" is wanting.

fect its own contraction. Indeed, we are not justified in affirming, absolutely, that there is even this difference of detail. It may not be the very same portion of the muscle which decomposes and contracts; the power and the mechanism may be as truly separate in the body as in any machine of our own contriving, and only so closely brought together as to defy our present powers of analysis. It is not unlikely that the framework (if we may call it so) of the muscle remains comparatively unchanged, and that fresh portions of material are continually brought to undergo decomposition. In this way, we might perhaps better understand the decadence of the body with advancing age; it may be literally a wearing out.

And, secondly, the dependence of the active powers of the body upon the decomposition of its substance was rendered difficult to recognise, by the order in which the facts are presented to us. Let us conceive that, instead of having invented steam-engines, men had met with them in Nature as objects for their investigation. What would have been the most obvious character of these bodies? Clearly their power of acting—of moving. This would have become familiar as a "property" or en-

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dowment of steam-engines, long before the part played by the steam had been recognised; for that would have required careful investigation, and a knowledge of some recondite laws, mechanical, chemical, pneumatic. Might it not, then, have happened that motion should have been taken as a peculiar characteristic belonging to the nature of the engine? and when, after a long time, the expansion of the steam coincident with this motion was detected, might it not have been at first regarded as consequence, and not as cause? Can we imagine persons thus studying the steam-engine backwards, and inverting the relation of the facts? If we can, then we have a representation of the course of discovery in respect to the vital functions. The animal body came before men's senses as gifted with a power of acting; this was, to their thoughts, its nature—a property of life. They grew familiar with this "property," and ceased to demand a cause or explanation of it, long before it was discovered that with every such exhibition of power there was connected a change in its composition. Only after long study, and through knowledge of many laws, was this discovery made. How then should they have done otherwise than put the effect before the cause,

and say, "The animal body has an active power, and as a consequence of every exertion of that power, a part of its substance becomes decomposed"?

This is another reason why the parallel between the living body and the machine has not been sooner recognised. The processes of nature are studied by us in an inverse order: we see effects before we discover causes. And such is the deadening effect of familiarity upon our minds, that the seen effect has often ceased to excite our wonder, or stimulate our demand to know a cause, before the discovery of that cause is made.

But there is yet a third reason for the difficulty that has been found in solving this problem of the nature of the animal functions. It is complicated by the co-existence, with the functional activity, of many other and different processes. The body is at the same time growing and decaying; it is nourished while it is dying. The web of life is complex to an unparalleled degree. Well is the living frame called a microcosm; it contains in itself a representation of all the powers of Nature. It cannot be paralleled by any single order of forces; it exhibits the interworking of them all. And those processes of decomposition which generate functional activity

are so mixed up with other vital processes, that no experiment can disentangle them. The relations of the various forces can be discerned and demonstrated only by the application of known laws of force.

Two sources of difficulty, arising from this complexity of the organic processes, may be specially noticed. On the one hand, there are certain changes which involve decomposition, and yet are probably not attended with any functional activity. The portions of the body which have given out their force in function, may pass into still lower forms of composition previous to their excretion as worn-out materials: a process of decay may go on in them, which does not manifest itself in any *external* force. And, besides this, the decomposition which is to bring into their orderly activity the various structures, must itself be of an ordered and definite character. Unregulated, or in excess, it would produce not function, but disease; as, indeed, we see in our own mechanical contrivances: not every possible expansion of the steam, but only that which takes place in definite direction and amount, can raise the piston.

But, on the other hand, a still greater difficulty

in tracing the relation of decay to function, arises from the admixture, with these changes, of the opposite ones which constitute nutrition. The watch is being wound up as it goes. Perpetually giving off its force in function, this force is as perpetually renewed from the world without. And the very organs which are active by decay are, perhaps at the same moment, being restored by nutrition to their perfect state. The disentangling of these processes may well be allowed to have challenged man's highest powers.

Let us now endeavour to apply the conception we have set forth to some of the animal functions, and see how far it is confirmed or otherwise; and, if true, to what point it carries us, and what further questions it suggests. We conceive, in the active structures of the body, a state of equilibrium very easily disturbed, existing between the chemical affinities of their elements, and a force which has opposed these affinities; and that, by the operation of the stimuli which excite function, this equilibrium is overthrown.

Let us consider first the nervous system. Evidently we do not take into account the phenomena of thought, feeling, or will. These form another

subject. But, confining our attention to those operations of the nervous system which are strictly physical in their character, it may be observed, that all the stimuli which excite them are adapted to bring into activity the repressed chemical affinities of the elements. Thus the nervous force is called into action by mechanical irritation, or motion, in whatever form applied, by changes of temperature, by chemical irritants, by electricity, light or sound, and by the taste or smell of bodies. It is hardly possible to perceive in these various agents any property in common to which their influence on the nervous system can with reason be referred, except the power they all, so far as they are known to us, possess of disturbing an unstable chemical equilibrium. Acting upon a tissue in which the affinities of the component elements are so delicately balanced, and the inherent tendency to change so strong, as in the nervous substance, it can hardly be otherwise than that they should overthrow that balance, and bring about a change of composition. "In compounds in which the free manifestation of chemical force has been impeded by other forces, a blow or mechanical friction, or the contact of a substance the particles of which are in a state of transforma-

tion, or any external cause whose activity is added to the stronger attraction of the elementary particles in another direction, may suffice to give the preponderance to the stronger attraction, and to alter the form and structure of the compound."[1]

And that a chemical change in the nervous tissue does ensue from the action of the stimulus, is proved by the fact that the same stimulus will not reproduce the effect until after the lapse of a certain interval. The necessity of time for the renewal of the irritability is evidence of an altered composition.

And may we not, in this light, form a clear and natural conception of the nervous force? A galvanic current, we know, results from chemical change in inorganic bodies. But when the nerves of any part are stimulated a chemical change is set up in or around them. When we touch any object, for example, the nerve-tissue undergoes such a change; the cellular substance which surrounds their terminations resembles to some degree the fulminating powders, and decomposes, though only to a limited extent, at a touch.[2]

[1] Liebig.

[2] In the original edition Hinton here inserts two figures showing the nerves of the fingers and their terminals magnified. There are numerous other illustrations through the earlier chapters of the book. It has not been thought necessary to reproduce them in the present reprint. The points

From the decomposition thus set up, is it not natural to believe that a peculiar force or current, might arise, *like* the galvanic, but not the same, because the chemical changes, though resembling those which take place in inorganic substances, are not the same? The nervous force originates in a peculiar chemical change, and is, therefore, a peculiar force. But, as its source is very similar to that of galvanism, so are its characters very similar also. It is like, but different, at once in its source and nature.

Or let us take the case of hearing. In the auditory nerve, the equilibrium is so adjusted as to be disturbed by the sonorous vibrations. An illustration of the nature of the action is furnished by the fact mentioned by Mr. Rogers, that masses of ice and snow of considerable magnitude may be precipitated from the Alpine ridges by the sound of the human voice; the gravitation of the masses, and the resisting forces which maintained them in their places, being in such exact equilibrium that this slight motion of the atmosphere suffices to give the

illustrated will now be more intelligible to those familiar with the elements of biological science than they were when the book was written, while readers who desire to test Hinton's statements will easily find figures for comparison in manuals of anatomy, physiology, and botany. (Ed.)

preponderance to the former. Of the chamois hunters of the Alps he says—

From rock to rock, with giant bound,
High on their iron poles they pass;
Mute, lest the air, convulsed with sound,
Rend from above a frozen mass.

This illustration, remote though it may seem, is valuable as bringing clearly before the mind the essential character of the process which constitutes the animal function. For the stimulus in this case, the aërial vibration, evidently produces the resulting motion only by disturbing the equilibrium of the counteracting forces.

So, too, the photographic process is a true analogue of the physical part of vision. To prepare a plate for photographic purposes, it is only necessary to apply to it, in solution, chemical substances which tend to undergo a change of composition, and the equilibrium of which is so unstable as to be disturbed by the rays of light. Thus prepared, the paper is called *sensitive*:—by a blind instinct, which is often truer than studied science; for the retina, or expansion of the optic nerve within the eye, is

like it. The retina consists of matter prone to change. Its elements tend to break up, and enter into new combinations. What supposition can be better warranted than that the rays of light entering the eye permit a change of composition, as they are known to do in respect to the photographic salts?

Mr. Grove by a beautiful experiment [1] has shown that light, falling on a plate prepared for photography, will set up a galvanic current. Does not this unavoidably suggest itself as an illustration of the process of vision? Light impinging on the retina determines therein a chemical change, which develops in the optic nerve the nervous force. This force sets up in the brain an action of the same order as that in the retina. Hence again originates a nervous force, which, conveyed back to the eye, sets up yet a third time a chemical change (in the iris), which causes the contraction of the pupil.

The views proposed by Pflüger, in reference to the effects of electricity applied to the nerves, are strikingly in harmony with this general idea. He finds all the phenomena best explained by the conception of a tension-force and a controlling force as

[1] On the Correlation of the Physical Forces.

existing within the nerve, the balance of which the electrical agencies variously disturb.

If we pass from the nervous to the muscular system, we find abundant confirmation of our position. Of the means by which the decomposition of the muscle causes its contraction in length, and so results in motion, there is as yet no certain knowledge; but chemical action is one of the best known sources of motor force, and one of the most frequently employed. The flight of a bullet and the motion of the arm are phenomena of a similar kind. The appearances presented by muscles during contraction have been carefully observed. All muscles consist of fibres, of which 10,000 on an average would about occupy an inch. Each fibre runs the whole length of the muscle, and is connected with the tendons in which almost all muscles commence and terminate. These fibres are of two kinds, simple in the involuntary muscles, and *striped* in those over which the will has control. The stripes are transverse markings on each fibre, as if it were composed of separate discs arranged in lines, and they afford a good means of examining the process of contraction. When a portion of fresh muscle is made to contract, under the microscope, by prick-

ing or otherwise irritating it, the markings, or striæ, approach each other, the muscle diminishing in length and increasing in thickness. The action is gradually propagated from the point of irritation to the adjacent parts, with a creeping motion, subsiding in one part as it reaches another, until it has traversed the whole length exposed to view. This is most probably the mode in which contraction is effected during life; and in persistent muscular efforts it is believed that the different portions of the muscle alternately relax and contract again, and that all the fibres are not active together. The contraction of muscle is attended with a slight rustling sound, which may be heard by moving the ball of the thumb vigorously, close to the ear. In contracting, a muscle is not merely shortened; it undergoes a change which modifies its entire structure, and will bear a very much greater strain without rupture than in its uncontracted state.

The causes which determine contraction in a muscle are those which induce its decomposition. When placed beneath the microscope, it is seen to contract first at any spot where it has been broken or otherwise subjected to injury. The slightest mechanical irritation induces a local contraction, as

does also the contact of air or water. In cases of lingering disease, in which the proneness to decay is increased, contraction of the muscles takes place with increased facility, and may often be excited by a touch. And the stimuli which, in health, induce action in the muscles most powerfully, are those which most strongly evoke their tendency to change of composition. Electricity, which ranks next to the nervous force as the exciter of muscular action, stands first among the physical forces as a promoter of chemical change, and is known to induce the speedier decomposition, after death, of muscles to which it has been freely applied.

But we must pass by many inviting topics, and hasten to notice one objection to the view that has been propounded, which should not be passed over, as it has probably weighed much with some minds. Certain stimulating substances, as alcohol,[1] coffee, or tea, have been found to increase the activity, while they diminish rather than increase the waste, of the body. This question can be properly dis-

[1] It is worth while to point out that the "objection" to his view which Hinton found in the supposed tendency of alcohol, etc., "increase the activity of the body" has ceased to exist. Scientific and medical opinion no longer regards alcohol as a stimulant but rather as a nervous sedative, and, in excess, a narcotic. A recent summary of opinion will be found, for instance, in Professor G. Catlin's little book, "Liquor Control," 1931. (Ed.)

cussed only after the subject of nutrition has been passed in review; but it may be observed that there are other processes of decomposition going on in the body, besides those on which functional activity depends. It may be that these stimulants diminish that final oxidation, which precedes, more or less completely, the elimination of the waste products from the body. Or it may be, though this is not probable, that these bodies contain more force in a less amount of substance than ordinary food. Of one thing we may be confident, that no articles of diet will give us the means of creating force, or of exerting power except at the expense of the power that is embodied in our food, and so is stored up within.

And now to what end is this discussion? What advantage is gained by adopting this view of the vital functions? First, a great simplification in our idea of the living body. In respect to one of its chief characteristics, the vital organism ceases to be contrasted with the rest of Nature, and becomes to us an example of universal and familiar laws. One form of force acting as a resistance to another, and so accumulating a store of power, which operates on a structure adapted to direct it to given

ends;—this is the plan on which the animal creation is constructed. It is the same plan that we adopt when we seek to store up force, and direct it for our own purposes. We imitate herein the Creator; humbly, indeed, and with how great an inferiority. But the principle is the same.

And some otherwise mysterious "properties" of living organs lose their mystery. The "contractility" of muscular fibre, and the "sensibility" of the nerves and brain, are seen to be, not mere inexplicable endowments, but names applied to the effect of their known tendency to undergo chemical change. Given the tendency to decompose, and the anatomical structure of the parts, and there must be a power to contract in muscle, and to originate the nervous force in brain.

And when, in this light, we consider the *vital* force, it presents no more the same unapproachable aspect. We exonerate it from one part of the task that has been assigned to it. The vital force is not the agent in the functions; they are effects of the chemical force which the vital force has been employed in opposing. And this is the office and nature of the vital force—to oppose and hold suspended the chemical affinities within the body, that by their

operation power may be exerted, and the functions be performed. When we ask, therefore, What is the vital force? we inquire for that force—whence it is derived, and how it operates—which in the organic world opposes chemical affinity. Reverting to the illustration of the watch, we have seen the functions to arise from the unbending of the spring; in the vital force we seek the agency that bends it.

This is a future task. But before we leave the subject that has occupied us now, let us take one glance at another analogy which it suggests. The actions of the body result from one form of force resisting the operation of another;—are not the revolutions of the planets regulated by the same law? Motion opposing gravity—these are the forces which (in equilibrium perpetually destroyed and perpetually renewed) determine the sweep of the orbs about the sun. Nor does observation reveal to us, nor can thought suggest, any limit to the mutual action of these kindred, but balanced powers. Life sets its stamp upon the universe; in Nature the loftiest claims kindred with the lowest; and the bond which ties all in one Brotherhood, proclaims one Author.

CHAPTER II

WHY WE GROW.

WE are continually dying. In all our actions force is given off, the very same force by which the body lives; and portions of our frame, accordingly, waste and are cast off. This process implies an opposite one. The life, constantly ceasing, is constantly renewed. Throughout the adult state nutrition proceeds *pari passu* with decay; in youth it is in excess, and results in growth; in age, the preponderance of the decay predicts the end. But new life springs from the old, and in its offspring the perishing organism repeats and multiplies its youth. How is this marvel wrought? By what agency does the perpetually failing life renew itself, and rise up fresh and vigorous from its ceaseless struggle with decay?

It is a wonderful thing—Life, ever growing old, yet ever young; ever dying, ever being born; cut down and destroyed by accident, by violence, by pestilence, by famine; preying remorselessly and insatiably upon itself, yet multiplying and extending

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still, and filling every spot of earth on which it once obtains a footing; so delicate, so feeble, so dependent upon fostering circumstances and the kindly care of Nature, yet so invincible; endowed as if with supernatural powers, like spirits of the air, which yield to every touch and seem to elude our force; subsisting by means impalpable to our grosser sense, yet wielding powers which the mightiest agencies obey. Weakest, and strongest, of the things that God has made, Life is the heir of Death, and yet his conqueror. Victim at once and victor. All living things succumb to Death's assault; Life smiles at his impotence, and makes the grave her cradle.

Truly it seems as if there were something here not only mysterious and wonderful (for that everything in Nature is,) but peculiar and unlike all beside. It seems as if a power had its seat in living things, which could maintain and extend itself by some inherent faculty, could subdue by a spontaneous operation surrounding forces, and hold in subjugation all that tended to its injury. And for a long while this view was entertained. It is natural; and until an extensive knowledge of the physical laws had been entertained, it seemed to be necessary. All have heard of the Vital Principle. This was the agent

supposed to reside in living things, and (either with conscious design or unconsciously) to build up, model, maintain, and use the organic frame.

This figment, however, has long been overthrown. The labours of physiologists have revealed the proofs of a profounder harmony in Nature. Life is strong, because it is dependent; immortal, because it draws its being from a perennial source. All things minister to it. The tender organic frame needs no self-preserving power within, because all the natural powers are its servants. The earth and air and distant orbs of heaven feed it with ceaseless care, and supply, with unfailing constancy, its wants. Life is in league with universal forces, and subsists by universal law.

For the growth and nourishment of organic bodies may be seen to result from well-known agencies, and to be in conformity with common and all-pervading laws. But, first, it is needful to limit our inquiries, and to mark out distinctly the question to be considered. The fable of the fagot of sticks which were easily broken one by one, but resisted all efforts when tied together, is peculiarly applicable to the study of Life, though its moral needs to

be read the other way. We must divide to conquer. We have discussed the active powers or "functions" of the body, and have seen them to result from chemical changes within it, by which (as by the relaxation of a tense spring) force is set free, and the characteristic actions of the various organs ensue. In living bodies chemical affinity has been opposed, so that they represent forces in a state of tension; their elements are arranged in a manner from which chemical affinity tends to draw them. The question we now propose is— By what means is this arrangement of the elements effected? The actions of the body, produced by chemical change within it (its partial and regulated decomposition,) have been compared to the motions of a clock, produced by the regulated gravitation of its weights. The present question, therefore, would be, How are the weights raised?

It is evident that this question does not cover all the ground that remains. It leaves on one side at least two distinct subjects—one the first origination of Life; the other, the FORMS which organic bodies assume. Neither of these questions comes within our present regard. Our inquiry is, how liv-

ing organisms grow and are nourished under existing conditions; and that only in one aspect of the case. For the body not only increases in size and weight from its first formation till maturity, but while this process is going on it receives a certain shape. It is not only *nourished* but *organised*. The various parts are fitted to each other, and the whole presents, in every order of creatures, a typical or specific form, which is, indeed, one of the chief distinctions of the organic world. But we do not here concern ourselves with this curious fact. We ask only, by what means new materials are added to the living body in its earlier stages, and waste is repaired when it has attained its perfect stature? How these materials are shaped into characteristic forms is a future question. We will take our fagot stick by stick.

To make clear our meaning, let us suppose ourselves looking at a portion of the white of an egg—albumen, as it is called. This has no power of performing actions; it has no defined shape; it is contained in the shell as it might be in any other vessel; it has not even any structure, such as fibres or cells, which the microscope reveals; it is simply a viscous fluid. Yet it is an organic substance. Life is

in it. It is, indeed, the basis of all animal structures, and the great source from which they are formed and nourished. That which constitutes it living is the mode in which its elements are arranged. It consists mainly of three gases (hydrogen, oxygen, and nitrogen,) and one solid (carbon,) with small quantities of other bodies, of which the chief are sulphur, phosphorus, and lime. But these elements are not arranged according to their ordinary affinities. Exposed to the air, albumen decays; the hydrogen unites with oxygen and forms water, and with nitrogen to form ammonia, while the carbon takes up another portion of oxygen to form carbonic acid. Similarly, the sulphur and phosphorus select some other ingredients of the albumen, or of the atmosphere, to unite with them into more definite compounds. In time, the process is complete, and from being an organic substance the albumen has wholly passed into a variety of inorganic substances. In doing so, it has given out a certain amount of force, chiefly in the form of heat (the temperature of decaying bodies is well known to be above that of the surrounding air); and this force, if the albumen had formed part of a muscle or a nerve, would have been operative in the function of the

same. Now it is on account of this force, which is in the albumen, and is not in the inorganic substances which are formed by its decay, that it is called organic. It could not be albumen without some force having made it so. Hydrogen, and nitrogen, and carbon, and oxygen would no more form albumen (against their tendency to form carbonic acid and water and ammonia,) without some force compelling them, than a stone would poise itself in the air (against its tendency to fall to the ground,) without some force compelling it.

We seek, then, the source and laws of the force by which the elements of the living body are placed in these relations to each other, and instead of forming the ordinary chemical compounds, are formed into organic substances. And here we turn to facts. Every one knows that decaying substances are the seats of life. The "mould" that infests the stores of thriftless housekeepers, and the fungi that grow on damp and rotting wood, are instances. These low forms of vegetation live on the decaying matter. Let us consider what takes place in their growth. On the one hand, the wood or other substance, in its decay, is giving out force; on the other, the developing plants are acted upon by force, and

are embodying it in their structure. One body is ceasing to be organic, and therein is giving off its force, and in immediate connection with it another body is becoming organic, and therefore is receiving force into itself. Can we be misinterpreting these facts in saying that the former process is the cause of the latter; and that the decay gives out the force which produces the growth?

To take an illustration. Conceive two watch-springs, one bent, the other relaxed (and the former somewhat the more powerful,) so connected together that the unbending of the one should cause the bending of the other. The bent state, here, would be transferred from the one spring to the other; the one would cease to be bent as the other became bent. But we have seen that the organic state of matter may be compared to the bent state of a spring; that it also is an embodying of force. Is it not quite as simple, then, that the "organic state" should be transferred from the decaying body to the growing one? It is, in each case, simply a transference of force from one to the other; of the presence of which force the organic state, like the mechanical tension, is the effect and sign. Thus, in the case of plants growing on decaying sub-

stances, the decomposing process in their food becomes an organising process in them; the force arising from the decomposition becomes, and is, their "vital force."

Let us trace the process again; the wood, as an organic substance, contains vital force; as it decays, it changes into inorganic substances (such as carbonic acid, &c.) in which there is no vital force. During this decay, therefore, the vital force that was in the wood has passed forth from it. What has become of it? Part of it has been given out as heat; but part of it, evidently, has been, as it were, transferred to the fungus which has grown at its expense. The wood *was* living, the fungus lives now; the wood has decayed, the fungus has grown; the wood, in its decay, has given out force; the fungus, in its growth, has taken up and embodied force, and is ready in *its* decay to give off again. The life of the wood has, in short, been transferred to the fungus. The force has changed its form, but it is the same force in both.

The fungus could not have grown if the wood had not decayed, the force would have been wanting; as in the action of a balance, one scale cannot rise unless the other falls. The living state is, in

respect to the force of chemical affinity, as the raised state is in respect to the force of gravity. When one scale of a balance falls, the "raised state" is transferred from it to the other scale; so, when one organic body decays and another grows upon it, the "living state" is transferred from the decaying to the growing body. It is transferred to the one while it ceases, and because it ceases, in the other.

In this instance the law of growth is presented to us. Matter is rendered organic, either through the decomposition of other organic matter, or through the medium of chemical processes which resemble that decomposition in giving out force. The nutrition of living bodies is, in brief, an illustration of the axiom that action and re-action are equal and opposite.

This is easily conceived if the perception of the organic state as involving an opposition to chemical affinity is kept before the mind. The decomposition of one portion of organic matter may cause other matter to become organic, as the fall of one portion of matter may cause another portion to rise. The downward movement generates force, the upward absorbs it; the fallen body represents the inorganic, the raised body the organic state. Or it is as the

downward motion of a pendulum develops the force from which its upward movement results; or as a heated body contracts while it cools, and causes expansion in the things around. But in truth, the possible illustrations are innumerable, for a process essentially the same is presented to us continually in nature under every variety of form:—a change of one kind producing its opposite. It is this to which (in its mechanical form) the name of *Vibration* has been applied; as when a tense string that has been deflected from the straight line is let go, its motion towards the central line reproduces the deflection; the one motion producing the force, which the other, as it were, uses, or absorbs.

The vital force, from carbonic acid, water, and ammonia, produces albumen; chemical force from albumen produces carbonic acid, water, and ammonia. These two processes are not only different, they are strictly opposite to each other, and because they are opposite, they are so closely interlinked. The opposition of life to chemistry is the secret of its source. Life is an action produced by its opposite. It has its root in death, and is nourished by decay.

The first suggestion of this view appears to have

been made by Dr. Freke, of Dublin, who, in a work "On Organization," published in 1848, endeavoured to show that for the origination or formation of one organic body, there is a necessity for the simultaneous disorganisation or decay of another; so that in all life both these processes are in operation together. His words are: "Thus are two essentially distinct and opposite processes concerned in producing the phenomena of active life; are of necessity in operation for the production of what we imply when we say of a thing, 'it lives'; and thus, too, it becomes apparent how death is essentially a part of life." Again, in some papers published in 1852, Dr. Freke says, in discussing the nature of the vitalising process: "We find that what one was obtaining, the other was losing; at the same time that the elevation of dead matter to the organised condition was in progress, another and directly opposite process was taking place: namely, the body which was conferring that organisation was itself undergoing the process of disorganisation; was itself descending in the scale of life."

Dr. Henry, also, of the Smithsonian Institute at Washington, has advocated the same doctrine. In a "Report on Agriculture," published in 1857, he

thus speaks, illustrating the general question by the growth of a potato: "If we examine the condition of the potato which was buried in the earth, we shall find remaining of it (after it has given origin to a young plant) nothing but the skin, which will probably contain a portion of water. What has become of the starch and other matter which originally filled this large sac? If we examine the soil which surrounded the potato, we do not find that the starch has been absorbed by it; and the answer which will naturally be suggested, is that it has been transferred into the material of the new plant, and it was for this purpose originally stored away. But this, though in part correct, is not the whole truth; for if we weigh a potato prior to germination, and weigh the young plant afterwards, we shall find that the organic matter contained in the latter is but a fraction of that which was originally contained in the former. We can account in this way for the disappearance of a part of the contents of the sac, which has evidently formed the pabulum of the young plant; but here we may stop to ask another question. By what power was the young plant built up of the molecules of starch? . . . . The portion of the starch, &c., of the tuber,

as yet unaccounted for, has run down into organic matter, or has entered again into combination with the oxygen of the air, and in this running down, and union with the oxygen, has evolved the power necessary to the organisation of the new plant."

A similar view has been argued by Professor Le Conte, of the South Carolina College, Columbia.[1] "It is well known that in the animal body there are going on constantly two distinct and apparently opposite processes, viz. decomposition and recomposition of the tissues; and that the energy of life is exactly in proportion to the rapidity of these processes. Now, according to the ordinary view, the animal body must be looked upon as the scene of continual strife between antagonistic forces, chemical and vital; the former constantly tearing down and destroying, the latter as constantly building up and repairing the breach. In this unnatural warfare the chemical forces are constantly victorious, so that the vital forces are driven to the necessity of contenting themselves with the simple work of reparation. As cell after cell is destroyed by chemical forces, others are put in their places by vital forces,

[1] See the "American Journal of Physical Science," November, 1859; or the "Philosophical Magazine," February, 1860.

until finally the vital forces give up the unequal contest, and death is the result. I do not know if this view is held by the scientific minds of the present day as a fact, but it certainly is generally regarded as the most convenient method of representing all the phenomena of animal life, and, as such, has passed into the best literature of the age. Certain it is, however, that the usual belief, even amongst the best physiologists, is that the animal tissue is in a state of unstable equilibrium; that constant decomposition is the result of this instability, and that this decomposition, and this alone, creates the necessity of recomposition—in other words, creates the necessity of food. But according to the view which I now propose, decomposition is necessary to develop the force by which organisation of food or nutrition is effected, and by which the various purely animal functions of the body are carried on: that decomposition not only creates the necessity, but at the same time furnishes the force of recomposition."

The phenomena of fermentation afford a test of the soundness of this conception. Vegetable juices during fermentation undergo a process of slow decomposition. If, during this process, certain peculiar

germs are present, a plant consisting of cells, and low in the scale of vegetable life, is developed. This plant is what we call the Yeast. Now, if the force given out by the liquid in fermenting be the cause of the growth of the plant, yeast should never be formed unless fermentation is going on. If, on the other hand, the growth of the plant be (as has been supposed by some) the cause of the decomposition, then fermentation should never occur unless the growth takes place. But it is well known that the yeast plant is never developed except during fermentation, while fermentation will take place, although more slowly, without any formation of yeast. It follows, therefore, that the growth depends upon the decomposition, and not the decomposition upon the growth.

But fermentation is excited by the addition of yeast, and proceeds more successfully in proportion to the rapidity with which the yeast cells are developed. Why should this be if the formation of the living cells is only the effect, and not the cause, of fermentation?

The intimate connection of growth and decay explains this fact. The yeast excites fermentation because it is itself exceedingly prone to decompose;

more prone than the liquid to which it is added. And in decomposing it communicates the impulse of its own change to the matter around it, so disturbing the equilibrium of the elements, and bringing about, in a few hours, chemical changes that would otherwise have occupied a much longer time. And this more active decomposition in the fermenting fluid reacts again upon the cells of the yeast, and produces in them a rapid growth and multiplication. They afford the outlet, as it were, for the force given out by the chemical changes to which they have furnished the stimulus.

In thus inducing a more vigorous growth by instituting, primarily, a more energetic decay, the effect of the yeast plant is analogous to many processes in the animal body. For example, there is reason to believe that the limbs are powerfully developed by exercise, and that muscles waste if not kept in use. But the action of a muscle depends upon an energetic decomposition in it, and in this more energetic decomposition of the active than of the inactive muscle, we may easily recognise the cause of its greater vital development. The stimuli which call it into functional activity produce

chemical changes in it, as the yeast does in fermentable liquids; and the larger growth consequent thereon is like the more abundant development of the yeast cells in actively fermenting fluids.

This effect may be illustrated mechanically. The pendulum rises by the force of its fall, and will be made to rise the higher by any impulse which makes its fall more rapid. This aspect of the subject is further illustrated in the *Appendix*.

Recognising this dependence of nutrition on decay, we have in our hands a clue which will guide us through the labyrinth of the vital phenomena. For the most striking, and at the first view the most marvellous aspect of life, is the coexistence and inseparable interlinking, in every part and process, of these opposites. Building up and pulling down, formation and destruction, results of chemical force and results opposed to chemical force, are ever going on together. Till the one class of operations is seen to be a consequence of the other, an air of impenetrable mystery rests over all. But if this relation is recognised, the entire cycle of physical life presents itself to us under a new aspect; and the problem of vitality, though peculiar in its

details, and of almost infinite complexity, is seen to belong essentially to a class of problems already solved.

Water regaining its level, and rising, as in an enclosed circuit it will do, by virtue of its fall, presents to us in a simple form the very same relations of force. "You see," says Bishop Berkeley, at the conclusion of his celebrated *Dialogues on Matter*, "the water of yonder fountain, how it is forced upwards in a round column to a certain height, at which it breaks and falls back into the basin from whence it rose; its ascent as well as descent proceeding from the same uniform law or principle of gravitation." May not a fountain, indeed, picture to us the relations of the forces in the organic body? How mysterious a fountain would be to an observer unacquainted with the law that water will find its level, and that a gravitating motion may produce a motion opposed to gravity! How like its continued upward and downward flow, with its hidden source, is to the intermingled processes of life; two opposites bound up in one, and presenting to us the effects of a single cause! For chemical force is to the organic body

as gravity is to the fountain, the source of all its actions, opposite though they are.

In a fountain the operation of gravity is regulated, and directed in a certain way, so as to produce, in the elevation of the water, an effect directly opposed to its own primary action; in life, the operation of chemical force is regulated and directed in certain ways, so as to produce, in nutrition, results directly opposed to its primary action. Thus chemical affinity, at the same time, produces and destroys the living frame, this gravity at the same time produces and destroys the fountain. There is a constant flux maintained by a hidden power: a mystery, necessarily, until the more mysterious simplicity and grandeur of the LAW are known.

We must take a larger view than we are naturally apt to take of the vital relations and extend our thoughts to embrace processes which do not present themselves immediately to our sense. There is in organic life, truly, a threefold process: the first link of which is a chemical operation external to the living frame itself, a part of the general force of Nature, of which the vital force is a particular form

and modification only. In the apparent aspect of living things, this primary operation is concealed from sight, and so it is naturally overlooked; as in a fountain the uninstructed eye takes no account of the previous elevation and fall of the water. Life seems to begin with the nutrition—an action opposed to chemical force; but we look further back, and recognise a precedent chemical change as the originating power. In respect to force, the chain is this: first, in the world around, an action due to chemical force; then resulting from this, a change opposed to chemical force, which is the nutrition of the living body; then again a chemical change, which is its function or decay. So in the fountain there is, first, the gravitating motion of the water, then the upward motion due thereto; and then again a gravitating motion.

And thus, too, we may discern in what the special characteristic of the vital process consists. It does not lie in the forces at work, nor in the laws according to which they operate. Physical life is a result of the natural laws, and not an exception to them; but the conditions are peculiar. As in a fountain the force of gravity, so in a living body the force of chemical affinity, receives a particular di-

rection; and instead of producing heat, or electricity, or motion, as it does in the inorganic world, it is made to produce a force which directly opposes its own effects. This special direction of the effect of chemical force is the peculiarity of life.

But why the peculiar substances which constitute organic bodies should be formed;—why the chemical force, thus acting, should produce the albumen, fibrine, and gelatine, of which animals chiefly consist, or the woody fibre which makes up the mass of vegetable structures;—is a separate question, and one on which at present much darkness rests. Not that it is a *peculiar* mystery. The formation of water from hydrogen and oxygen, or of chalk from carbon, oxygen, hydrogen, and lime, in obedience to their chemical affinities, is no more understood than the formation of albumen from these and other elements in opposition to the affinities which draw them another way. When the chemist has told us why two gases, chemically united, should form water, he may ask the physiologist with a good grace why four or five gases and solids, vitally united, should form albumen. These two facts rest on the same basis. The relation of what the chemist calls "elements" to the substances formed by their

union, is one on which science is yet almost wholly silent. Meanwhile the relations of the forces concerned are capable of a separate demonstration, and we need not delay, until we know why albumen or fibrine should be formed, our inquiry into the laws displayed in their formation.

CHAPTER III

THE VITAL FORCE.

THUS we have clearly before us the idea of the organic state as one of *tension*, dependent upon an opposition to chemical affinities. And we see, too, how this tension is produced, at least in some cases: namely, by the previous operation of those very affinities themselves. But some interesting questions suggest themselves here, to which it is in our power to give at least probable answers. We may ask whether this dependence of the living state on chemical action is universal; or whether other forces, such as light and heat, may not also directly produce it? There appears reason to believe that the latter is not the case; but that a process of chemical change is always connected with the vitalising of matter, and that any other forces which contribute to this end do so by first exciting chemical activity. Where the latter is not present, no amount of other force suffices to induce the vitalising process. And so far from these other forces being always absorbed when growth is in progress,

we see a notable instance of the contrary in the germination of the seed, which is attended with a decided rise of temperature. It appears that here the amount of chemical change is in excess of the vital action consequent upon it, and that, therefore, while a part of the force it generates goes to reproduce the vital state, and bring about the growth of the young plant, part of it passes off as heat. So too, in some of the functions of the animal (muscular motion, for example,) the decomposition of the tissues seems to generate more force than the function consumes, and the temperature rises.

The part played by the various other forces which are known to contribute to the process of vitalisation (of which heat and light are the chief) would seem, therefore, to be either that of furnishing the conditions for chemical action, or of adding to its intensity. In both these ways their influence is essential. The effect of a moderately high temperature in facilitating chemical changes is well known, and its influence upon life can be perfectly understood upon that ground. Each tribe of living creatures seems to have a range of temperature within which its vital processes can be most per-

fectly carried on; as we see in the hibernation of some warm-blooded animals during the winter, and the similar state of inactivity to which warmth reduces certain of the reptile class. On vegetable life the influence of heat is so predominant, that Boussingault has made it the basis of calculation, and states that the same annual plant, in going through its complete development in different climates, receives on the whole the same amount of solar light and heat, its time of growth being shorter or longer, in strict proportion to their greater or less amount.

But further, in order to see fully the relation of chemical action to the production of the vital state, it is necessary to have recourse to the conception of a resistance or limitation to it. A natural action, such as the fall of a heavy body, as we have seen, may bring about a condition opposite to itself; it is the law of vibration: but in order that it may do so that action must take place under resistance, or must be incomplete. The pendulum rises from the effect of its fall, because that fall is partial, and fails of reaching the attracting body. If it fall to the earth, though the law of its action and the total amount of the effect produced are the same, yet the practical result is different. Other forces,

such as heat and sound, are produced, but the raised condition of the falling body does not re-appear. It is the same with the vibrations of a string; the tension which is necessary before vibration can be induced in it seems to introduce a resistance to the full recoil of the particles upon each other, so that their partial return after being drawn aside carries them again asunder. Now a similar thought respecting the chemical action which is the cause of growth, seems to be appropriate to, and demanded by, the facts. Living matter appears to afford such a limitation to chemical change, when taking place in relation with it, and so it educes a vitalising action from that change. It gives this direction to the force generated by decomposition, or by other processes of chemical union, by holding them as it were in partial check, and causing the chemical tendencies to fall short of their full satisfaction. Nor is a power of limiting chemical processes on the part of organic bodies a mere supposition; it is a power which they are known to possess, which is, indeed, on of their most obvious and familiar properties. Living bodies are distinguished by their resisting to some extent the operation of chemical forces; and to this resistance their power of causing

chemical change to produce living matter may be referred. When the forces are too great, and overcome the resistance, then there results from them only decomposition. They run on to the destruction of the organic state, and the dissipation (in heat or other inorganic forms) of the force that it embodied.

It thus appears that the origination of organic Life in Nature remains an open question. Our knowledge extends at present only to its reproduction and increase. To these there is a sufficient key in well-known laws; and they may be carried to any extent without demanding the supposition of other than familiar agencies and established principles. But the question of the first arising of the living state, the primary direction of the chemical or other force to produce an organic arrangement of the elements, remains as yet undecided. There is no difficulty in conceiving such a modification of chemical action to arise in accordance with the natural laws; and that there should be forces existing which must operate, under given circumstances, to determine the organic arrangements of elements when it does not exist before. Indeed, M. Berthelot's experiments, in which some

of the simpler organic substances have been formed from their elements by the application of force in the laboratory, seem to exhibit this very fact before our eyes.[1] And the differences pointed out by Professor Graham [2] between the two great divisions of matter (the crystalline, and the colloidal or gelatinous) have a most suggestive bearing in the same direction. He remarks respecting the latter (or colloidal) substances, that they contain force; "the probable primary source of the force appearing in the phenomena of vitality." He shows, too, that there are many other forms of this kind of matter besides the organic: the hydrated silicic acid, for example, from which in geological periods flint appears to have been formed. He compares these substances to water kept from freezing at a temperature below 32°, or to a saline solution more than saturated with the salt, and ready to crystallize on the slightest shock;—a condition of tension essentially the same as that which is the great distinction of the organic substance. But still we do not know in what way the organic state of matter

[1] "La Chimie Organique fondée sur la Synthèse." Par M. Marcellus Berthelot.

[2] "On Liquid diffusion as applied to Analysis." "Philosophical Transactions," 1861. Gum, or starch, or isinglass, may be taken as examples of colloidal substances.

may have arisen in nature. We are equally in the dark, indeed, as to the origination of any of the other forces or arrangements of elements; and the entire body of our knowledge must be advanced before we can satisfactorily discuss it. The difficulty is increased by the absolutely contradictory results, hitherto, of the experiments made by different observers to ascertain whether organised bodies arise in infusions of vegetable matter, without the presence of germs from which they may be developed. Each man will probably entertain his own opinion. My own is, that both organic matter and organised creatures did probably, and possibly may still, arise in the ordinary course of nature.

It is indeed remarkable that in the teeth of the words of Genesis,[1] the religious sentiments of men should have been roused against the opinion that the earth and the waters brought forth, or might

[1] The words are thrice repeated: "And God said, Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself upon the earth: and it was so. And the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself after his kind." And again: "And God said, Let the waters bring forth abundantly the moving creature that hath life, and fowl that may fly above the earth, in the open firmament of heaven. And God created great whales and every living creature that moveth, which the waters brought forth abundantly after their kind." And again: "And God said, Let the earth bring forth the living creature after his kind, cattle and creeping thing and beast of the earth after his kind; and it was so." Genesis i., verses 11, 12, 20, 21, 24.

be supposed probably to have brought forth, living creatures. And more especially does this appear strange when we find that the natural and obvious meaning of the words is still further established to be in favour of what has been called "spontaneous generation," by the arguments founded on them by some of the Christian Fathers: Saint Augustine urging, on this very ground, that the assembling of the animals in the ark must have been for the sake of prefiguring the gathering of all nations into the Church, and not in order to secure the replenishing of the world with life.[1]

That there is nothing which ought to excite distrust in the view of the, so called, spontaneous origin of living creatures may be further confirmed by a curious passage which occurs in Bacon's *Atlantis,* and which, irrational though it doubtless is, shows in which direction his judgment tended. "We make a number of kinds of serpents, worms, flies, fishes, of putrefaction, whereof some are advanced (in effect) to be perfect creatures, like beasts or birds. . . . Neither do we this by chance, but we know beforehand of what matter and

[1] Quoted in the first volume of "Cosmos."

commixture, what kinds of those creatures will arise."

We dismiss, however, as premature, any discussion of the origin of organic life, or consequently of the vital force. But we perceive that from our present point of view the vital force exists simply in a peculiar arrangement of elements, involving a tension of a special kind. By whatsoever means this arrangement may be produced, the force thus embodied in it is equally called vital. The characters of the force are due to that arrangement; they flow from it rather than are concerned in its production: just as in the case of the other forces, such as heat or electricity, the peculiar properties they manifest are the results and not the causes of the states of matter in which they consist.

The vital force, then, is like the other forces in nature in this, that it causes, or exists in, a state of tension; it is peculiar in respect to the characters of the tension in which it is exhibited. One of these characters is so striking and universal as to deserve especial mention. An almost constant process in the rendering inorganic matter organic is the giving off of oxygen; as constant in the return to the in-

organic state, is its absorption. The whole process may be said to constitute a great de-oxidation and re-oxidation: the de-oxidation produced by force and constituting a tension; the re-oxidation a return, a rebound as it were, to the former state, reproducing the force. And on the constant supply of oxygen all functional power, and therewith the continuance of the life, depends. The living body and the atmosphere around it constitute an inseparable whole. The once united elements still retain, in reality, their coherence—put asunder by force, and for temporary purposes, but pledged as it were to a deeper and inviolable union. In the reuniting of the parted elements is effected the end of the whole process, the functions of animal life. Complex, wonderful, and beautiful as it is, surely the wonder and beauty of the organic world rise in this view to a yet greater height. For in the de-oxidation and re-oxidation of the hydrogen in a single drop of water, we have before us, truly, so far as force is concerned, an epitome of the whole of life.

Thus, too, it appears that the production of the organic state is a true chemical analysis. In endeavouring to appreciate it, we must not limit our

attention to the organic substances themselves; we must comprehend in our view also the liberated oxygen; otherwise we receive a false impression. Between all organic bodies and the oxygen around, a tension exists, which is of the essence of their being. By any one with a competent knowledge of unchangeable relations it might have been foretold, seeing the nutrition achieved by the plant, that the animal must breathe. The vital air does but give us back our own;—our own, though by the lack of it we live.

And thus we need not, as indeed we cannot rightly, regard the organic substances as maintained by an affinity among their elements. For these substances have an onward and outward look; they imply a reference to something apart from themselves. The imprisoned gases pine for their wonted partner, and stretch themselves out towards their destined liberator. Set free from constraint their affinities operate again, and the materials of the living body and the atmosphere re-unite themselves. But no "affinity" need be supposed to hold together the organic substances; their elements are coerced into union by extraneous force, not drawn to it by attraction from within. In this respect these sub-

stances are like the inorganic compounds in which force is embodied, such as gunpowder, in which the components are placed side by side in definite proportions, but are not united to each other. The organic substance is analogous rather to the mixed gases of oxygen and hydrogen, resulting from the decomposition of water, and ready to explode on the application of an electric spark, than to a compound united by affinity.

But in considering the source of the force contained in organic bodies, we must not forget the frequent presence in them—the constant presence in all their most active portions—of nitrogen, solidified as it were from that gaseous condition to which it has a constant tendency to return. The presence of this same element, in the like solidified form, characterises also the explosive compounds; gun-cotton, for example, being formed by saturating the fibre with nitrogen. It is hardly to be doubted that one great element in the tendency of living structures to decompose, and to exert force, consists in the tendency of the nitrogen to escape from the bondage in which it is thus placed. And so a part of the activity of the body would be due to the coercion, not of the chemical but of the

mechanical properties of its constituents, by the union into which they have been forced.

For an example of the application of the idea of Life, as a twofold operation of one force, to the details of animal existence, we may refer to the development of the caterpillar into the moth, which is generally accompanied (as in the case of the silkworm) with a special activity of secretion. The silk is produced through a decomposing process; it is less living than the blood or tissues from which it is derived. Part of the force that was embodied in these has been given off; one portion of the creature's substance has sunk lower. May we not well believe that the remaining portion, through that sinking, has risen higher? To this very secretion we may trace the force by which the vital condition of the insect is elevated to a correspondence with the demands of the higher organisation it is destined to assume. By the operation of this simple law, the creature itself is furnished with protection and warmth, and fitted for its new life, while man's activities are evoked and his pleasures multiplied.

And looking beyond particular instances to the general relations of organic life, we see how beautifully it is adapted, as it were, to lean upon the

general breast of Nature, and be by it continually supported and renewed. It is a channel through which the ever-present energy of Nature works—an open course in which its forces may flow. All Nature, indeed, to the eye that traces its hidden powers and deeper workings, is visibly pressing around the plant and compelling it to live and grow. It has simply to receive and to be passive; its labour is done for it. It toils not, neither does it spin; but it yields itself freely to obey.

CHAPTER IV

MORPHOLOGY.

THE builder of an organ, it has been said, must be a wise man; and the non-mechanical part of the world will willingly concede the point. We wonder at a skill and forethought which can create from passive wood and metal an instrument so elaborately planned, so subtly tuned to harmony. It is a grand example of man's dominion over matter. So with any other mechanical triumph: we not only admire, but on man's behalf we are proud of, the chronometer, the steam-engine, the thousand contrivances for abridging labour with which our manufacturing districts abound. But suppose there were a being around whom all these things grew without his altering by his own exertion the operation of one of the natural laws; who could show us that the natural forces, the properties involved in the things themselves, called into existence wheel, or lever, or pipe, and fitted them into orderly connection to achieve his ends; and could demonstrate to us for each useful or beautiful result a chain of

causation reaching to the heart of all things: were not that more wonderful—infinitely more?

And so if we could discover for the exquisite forms of living things, for that marvellous grace of vegetable life which fills us with a wonder ever new, and a delight that familiarity cannot deaden—for the astonishing adaptations of structure in the animal frame, which, though yet but half revealed, even science dwells on with a reverent awe—if for these things we could discover a cause that would link them with the heart of all things, should we not be glad? Should we not feel that a secret not less than sacred had been revealed to us?

Life is lovely every way. Even if we look upon it as an isolated thing, existing apart from the rest of nature, and using the inorganic world merely as a dead pedestal on which to sustain itself, it is still beautiful. Not even a narrow thought like this can strip it of its charm. But narrow thoughts like this have unhappily the power of drawing a veil around the eyes, and closing up the heart until it clings to baseless vagaries of fancy as if they were consecrated truths, and shrinks from nature's deeper teaching with superstitious dread.

How lovely life were if it were but a revealing!

the bright blossom wherein nature's hidden force comes forth to display itself; the necessary outpouring of the universal life that circulates within her veins, unseen. How lovely, if life were rooted in nature's inmost being, and expressed to us in the most perfect form the meaning of the mighty laws and impulses which sway her, and which, as written on the seas, and rocks, and stars, is too vast for us to grasp: the bright and merry life, with its ten thousand voices, bursting forth from the dim and silent Law which rules the world, as in the babbling spring, the stream that has run darkling underground bursts forth and sparkles to the sun.

If we carry this thought with us, and remember that nothing can make life less beautiful or less divine, but that to see life essentially involved in nature, and flowing as a necessary consequence from her profoundest laws, would make those laws, to us, unutterably more divine and beautiful, we can enter into the spirit of a remonstrance which Bacon addressed to the men of his age, and may feel, perhaps, that it is even yet not out of date:—"To say that the hairs of the eyelids are for a quickset and fence about the sight; or that the

firmness of the skins and hides of living creatures is to defend them from the extremities of heat and cold; or that the bones are for the columns, or beams, whereupon the frame of the bodies of living creatures is built; or that the leaves of the trees are for the protecting of the fruit; or that the clouds are for watering of the earth; or that the solidness of the earth is for the station and mansion of living creatures; and the like: is well inquired and collected in metaphysic, but in physic they are impertinent; nay, they are indeed but remoras and hindrances, to stay and slug the ship from further sailing, and have brought this to pass, that the search of the physical causes hath been neglected and passed in silence."

"The search of the physical causes hath been neglected and passed in silence." Is not this still true in respect to the form and structure of living things? Partly a genuine and natural wonder at the exquisite beauty and perfection of their adaptations—which fill the mind with a sense of rest and satisfaction, as if their beauty were sufficient reason for their being, and exonerated the intellect from inquiry into the means by which they are effected—and, partly, feelings less to be com-

mended, have stayed and slugged the ship of science from further sailing here.

But this is greatly to our loss. We cannot tell, indeed, how greatly to our loss it may be; or what insight into grand, or even materially useful, laws we thus forego. This much is evident, that we lose thereby the opportunity of discovering whether there be proof of that unity of the vital and other laws, which, if it exist, it would delight and amaze us so to recognise, and which would justify us in raising to a level so much higher, our entire conception of the scheme of creation. For it is by the discovery of the *physical* causes of the results we witness in life, that the evidence of this unity must be given. The study of the *final* causes, or uses aimed at, true and beautiful as it is, tends rather to separate than to unite the organic and the inorganic world. We are apt so to put asunder in our thoughts what God has joined together, and (if we are not watchful of ourselves) may seek to elevate the one by degradation of the other.

To trace the ends achieved by living forms—the adaptation of the eye to light, of the ear to sound, the dexterous grace of the hand, the stedfast balance of the foot, the strength of bone, and

delicate response of nerve to Nature's lightest touch, is a delightful task, and endless as it is delightful. To turn from this pursuit (which ever allures us on, and makes our labour its own immediate reward,) and seek mere passive causes in the physical conditions which make these things necessary, might seem to be, if a needful sacrifice for science's sake, yet still a sacrifice, and a descent to lower ground. But it is not really so. How often in our experience it happens that the apparently uninviting study becomes full of the intensest interest, and yields the richest fruit. Not the flowery meadow, but the steep and rugged path, leads to the mountain's top; and he who in studying living forms contents himself with enjoying their beauty, and tracing their design, sports like a child with flowers in the vale, and foregoes the wider horizon and the clearer day which reward him whose toilsome feet achieve the summit.

Is the study of Living Form so hard and tedious, then (and chilling too,) that nothing but climbing up a mountain can be compared to it? By no means. It is of an almost incredible simplicity. And this is the wonder of it. The simplicity of the mode by which organisation is brought about increases

a hundredfold the wondrousness of life, and adds the new mystery of an almost inconceivable economy of means to the already overwhelming mystery of multiplicity and grandeur in the ends.

It is in life as it is in thought—the matter is furnished from one source, the form from another. Nature divides her work, and has recourse to a twofold agency. To one man she assigns the task of originating the new thought; to another that of imparting to it a fitting shape, and adapting it to the uses of mankind. So discoveries become known and spread. The populariser succeeds to the philosopher, and the knowledge that would else have been wasted on a few becomes available for all. The "how" is no less essential than the "what." Just so it is in respect to life. Because it is wrought into shapes of exactest harmony, and complex and subtle adaptation, the organic world bears its preeminence. The living matter were of little avail without the vital form. To no purpose were the forces of nature (grasped, as we can hardly help thinking, in a living and friendly hand) modified into the vital mode of action, and directed to the production of the marvellous organic substance, if a power were not present to receive and tend it, to

mould it into beauty for delight, and knit it into strength for use.

And what this power is, a little observation will reveal to us. It may be traced in every wayside plant, and lies hidden in every bud, for example, a leaf of the Potentilla. While the central leaflet is nearly symmetrical, the two lateral leaflets are very decidedly unsymmetrical, the superior half of each being smaller than the inferior. It appears as if the upper edge of the leaflet had been trimmed. If now we take a leaf at an earlier stage of its development, the cause of this difference in form, or at least one of its causes, will be evident. The different leaflets are evidently not similarly circumstanced: the lateral ones are so folded that while their lower halves are free, their superior halves are in contact with the central leaflet and with each other, and are so impeded in their growth. The central leaflet, lying equally between them, expands equally on each side. The common strawberry leaf shows the same form, arising in the same way.

If we consider the leaf further, we perceive, however, that not only are the leaflets on the sides modified in their form by the conditions under which they have grown, but that the central one is

modified also in not less degree. Evidently the lower halves of the lateral leaflets exhibit the natural and unimpeded growth of the part. The central leaflet, though resisted equally on both sides, and therefore symmetrical in form, yet has been formed under resistance. The free or perfect leaflet would be represented by the union of the two lower halves of the lateral leaflets. The difference of this form from that of the central leaflet indicates the effect of the pressure exerted on the latter by the adjacent parts.

Or let us pass to another simple object, a pea which has been made to germinate in water. The radicle has grown freely into a spiral form; the plumule has risen up into a curve. Of the spiral radicle we shall speak by-and-by; at present let us look at the plumule. Would it be thought that a great and most important law in the production of organic form is here exhibited? But it is so. The reason of the bent-up form which the plumule assumes is easily discovered. The end of it is fixed by being embraced between the two halves (or cotyledons) of the pea and the stalk, therefore, as it lengthens, necessarily grows into a projecting curve. It is a result of *growth under limit.* Does it

not seem almost puerile to make matter of special observation of such a thing as this? Yes, it is puerile; it is like a child. And the kingdom of science, Lord Bacon has observed, is like the kingdom of heaven in this, that only becoming as a child can it be entered.

Every organ of the body begins in this very way: by a curved projection of the growing substance. Let us look, for instance, at the first-formed organs in the development of the chicken within the egg; they are slight elevations, and are called the "Dorsal Plates," because they are gradually developed into the spinal column.

These elevations are formed out of a layer of cells called the "germinal membrane," from which all the parts of the bird are gradually evolved. Can we help asking, whether this may not be a case like that of the growing pea? Whether these *ridges* are not formed because the membrane is *growing under limit*, and is expanding in length while its ends are fixed?

If we should ask this question, there are facts which will enable us to answer it. The layer of cells *is* growing under limit; it is contained in a dense

capsule or external membrane, which does interfere with its free expansion. There is proof that this is the case. The cells of which the germinal membrane consists when it is first formed are nearly round, and lie in simple contact with each other. But after a short time, as they grow, their shape changes. They become pressed together by the resisting capsule, and present a hexagonal appearance. No one doubts that this change in the form of the cells is due to the pressure arising from their increase under limit. Can we doubt, then, that the rising up of the dorsal plates is due to the same cause? in fact, that it is just such a rising up as we see in the plumule of the pea? If we spread a handkerchief on a table, place the hands flat upon it a little way apart, and gradually bring them nearer to each other, we produce similar ridges.

The frond of a common fern again illustrates the process. Every one has noticed how it is curled, when young. It looks as if it had been rolled up. But this is not the case; it may easily be seen that it cannot be. There has not been a flat frond which could be curled up. It *grows* into this form, because the central part grows, while the ends are fixed.

With the increase of the plant it becomes free and uncurls; but it has never curled. The curling is an appearance due to its growth.

Or let us take another class of forms. The buds of plants almost always grow in the axils of the leaves. It is not hard to see a reason for this. The axil is the interval between the leaf and the stem; a kind of vacuity or space, into which the growing tissues may most easily expand. All the rest of the surface of the stem is covered in by the hard resisting bark, but where the leaf separates this resistance is diminished. It is the joint in the armour. So, in many rapidly growing plants, if a leaf be wounded a bud springs from the spot. The wound constitutes an artificial "axil." So, again, in "budding," a wound is made to enable the new root to grow.

One reason, then, why buds come in axils surely is, that there the least resistance is offered to the expansion of the soft substance of the plant. If we turn, again, to the development of the bird, we shall find what is precisely analogous.[1] Very many of the organs are formed, like buds, in axils, the brain consisting then of three small lobes.

[1] It is the same in all vertebrate animals, but the bird is most easily examined.

Now, in the interspaces or axils between these lobes, the eye and the ear bud out. These organs grow where a free space is afforded for them, at the points of separation between the lobes which, at this early period, constitute the brain. The eye "buds out" between the first and second lobes, the ear between the second and third. They are at first hollow protrusions, merely, of the substance of the brain. The attached portion, or "pedicle," lengthens and becomes relatively smaller afterwards, and constitutes respectively the optic and auditory nerve.

Or, let us look at the fully developed brain of any of the higher mammalia. The surface is wrinkled up in all directions, constituting quite a maze of elevated ridges, called *convolutions*. Do not these recall the "dorsal plates"? Are they not evidently formed in the same way? The external layer of the brain, expanding beneath the dense resisting skull, is folded into these "convolutions" for lack of space.

Surely, we have thus discovered one of the causes of the forms of living things, in the mechanical conditions under which they are developed. The chemical forces, as we have seen, are used to produce the living substance; mechanical force, in the

resistance of the structures which surround the growing organism, is used to shape it into the necessary forms. This is nature's division of labour. These are the simple means employed by the Creator for bringing into being the marvels of the organic world. Chemical force stores up the power, the mechanical resistance moulds the structure. We shall see this more truly by-and-by.

For the question arises, how far this reference to mechanical conditions may be carried. Evidently that cause is operative, but is it the only one? In answer to this question, we may say first, that, since the mechanical conditions present during its formation do, to a certain extent, determine the structure which the growing organism assumes, and may be seen to produce some of the beautiful and useful forms which it displays, we may not assume other causes until it is proved that these are insufficient. Here is a fact: the mechanical conditions under which plants and animals are developed have a power of determining their forms in the right and necessary way. The limit of this power must be learnt by observation.

Or, if we look at the matter in another way, the conclusion is equally evident. Let us consider

for a moment the circumstance of a developing plant or animal. Here is the living substance; it is a soft, plastic mass increasing in size; the forces of nature are operating upon it, adding to its bulk. Around it is a more or less resisting envelope. Will it not necessarily grow in those directions in which its extension is the least resisted? The case is, to a certain extent, like that of taking the copy of a medal in wax—it is a very rough comparison, but still it may help us to grasp the general idea; the plastic substance, under the pressure of the artist's hand, moulds itself into the desired form by extending where the resistance is the least. There is no possibility of it doing otherwise. The case is as demonstrable as a proposition in Euclid. And it is equally so in respect to the growing plant or animal; under the pressure arising from the increase of its mass, it will mould itself by extending where the resistance is the least.

But the process, of course, is much more complex than in this simple illustration. Perpetual changes and modifications are taking place, and especially in this respect, that every step in the development has its share in determining all that follow. Every newly-formed part or organ, each

minutest fold, becomes at once a factor in the process. Thus it is, of course, that from seeds, all of them so much alike, their widest diversities being apparently trivial, the infinite variety of vegetable form arises. The slightest incipient diversities are continually reproduced and multiplied, like a slight error in the beginning of a long calculation; and thus very trivial differences of form or structure between two seeds may generate an absolute unlikeness in the resulting plants.

But the true evidence of this law of living form is that which every one may find for himself. Every part of every creature, in which the means of its formation can be traced, will furnish it. If the bud of any flower be opened at an early stage, it will be seen how the petals grow into shape, modelled by the enclosing calyx; how the stamens are leaves that have not been able to unfold, and the anthers exactly fill the cavity of the bud, receiving thence their form. Or if the pod of the common pea be opened at various periods, the formation of the pea within it may be traced, under the influence of the like conditions; the plumule growing between the cotyledons when their expansion is resisted, and being itself a bud formed in an axil.

Everywhere may be discerned more or less clearly a plastic expanding tissue, modelled by the varying resistances it meets. In individual instances, no observer has been able to ignore this fact. "I fear," says Mr. Ruskin, in a recent volume,[1] discussing the formation of the branches of trees by fibres descending from the leaves—"I fear the reader would have no patience with me, if I asked him to examine, in longitudinal section, the lines of the descending currents of wood, as they eddy into the increased single river. Of course, it is just what would take place if two strong streams, filling each a cylindrical pipe, ran together into one larger cylinder, with a central rod passing up every tube. But as this central rod increases, and at the same time the supply of the stream from above, every added leaf contributing its little current, the eddies of wood about the fork become intensely curious and interesting; of which thus much the reader may observe in a moment, by gathering a branch of any tree (laburnum shows it better, I think, than most), that the two meeting currents, first wrinkling a little, then rise in a low wave in the hollow of the fork, and flow over at the side, making their

[1] "Modern Painters," vol. v. p. 46.

way to diffuse themselves round the stem. Seen laterally, the bough bulges out below the fork, rather curiously and awkwardly, especially if more than two boughs meet at the same place, growing in one plane. If the reader is interested in the subject, he will find strangely complicated and wonderful arrangements of stream when smaller boughs meet larger."

The reader will perceive how exactly this description and figure illustrate the principle. But no enumeration of instances could do justice to the evidence, or have any other effect than that of making the unlimited seem scanty. The proof is everywhere. One general fact may be referred to—the universally spiral form of organic bodies. The most superficial glance reveals a spiral tendency as a general characteristic both of the vegetable and animal creation; but a minute examination traces it in every detail. An essentially spiral construction is manifested from the lowest rudiments of life, upwards throughout every organ of the highest and most complex animal. The beautifully spiral forms of the branches of many trees, and of the shells which adorn the coast, are striking examples merely of an universal law. But the spiral is the

direction which a body moving under resistance ever tends to take, as may be well seen by watching a bubble rising in water, or a moderately heavy body sinking through it. They will rise or sink in manifestly spiral curves. *Growth under resistance* is the chief cause of the spiral form assumed by living things. Parts which grow freely show it well;—the horns of animals, or the roots of seeds when made to germinate in water. The expanding tissue, compressed by its own resisting external coat, wreathes itself into spiral curves. A similar result may be attained artificially by winding a thread around a leaf bud on a tree, so as to impede its expansion; it will curve itself into a spiral as it grows. Very fine [illegible]

The formation of the heart is an interesting illustration of the law of spiral growth. That organ originates in a mass of pulsating cells, which, gradually becoming hollow, gives the first form of the heart in a straight tube, more or less subdivided, and terminating at each extremity in blood-vessels. This is the permanent form of the heart in many animals. When the organ is to be developed into a more complex form, the first step in the process is its twisting. It is like what takes place when we

hold a flexible rod in our hands, and gradually approximate its ends. The straight tube is growing within a limited space, and therefore "coils itself into a spiral form." And this fundamental form it retains throughout all its subsequent development.

But if this principle is true, why has it been overlooked? and why have men fallen into a way of speaking as if living matter had some inherent tendency to grow into certain forms, or as if the masses of cells could model themselves, by some faculty or power of their own, into elaborate and complex shapes?

It seems a strange thing that they should have done so, and yet it may easily be accounted for. The simplicity of nature's working is too profound for man's imagination to fathom, and is revealed only to humble seeking and stedfast self-control. Never could men have *guessed* that through such means such results could be achieved, even by a skill they deemed divine. And if we ask why it was not examined and observed long ago, the answer is, that other causes had been invented, and men had made up their minds. There was a "plastic power," a "specific property," a "formative *nisus*,"

or "effort." Shall we go on with the list? Is it any wonder that men could not see a simple, commonplace fact like this—that living things grow as they cannot help growing?

And, truth to say, there is all excuse for them. Nature is a wise and patient instructress of our ignorance. She never hurries us; but is content that we should read her lesson at last, after we have exhausted all our guesses. Has the reader ever taught a child to read, or watched the process? If so, he has seen a "great fact" in miniature; the whole history of science on a reduced scale. For will not the urchin do any conceivable thing rather than look at the book? Does he not, with the utmost assurance, call out whatever letter comes uppermost, whatever word presents to his little imagination the slightest semblance of plausibility? He never looks until he cannot guess any more.

Mothers are patient, Heaven be praised; but not so patient as our great Mother. For when the young rogue, finding it is of no use to guess any more, says, in mock resignation, "I can't tell," the maternal indignation will sometimes flash forth. But when we, finding that the mystery of life will not yield to our hypotheses, say, "We cannot learn it;

it is a mystery insoluble," no sound of impatience or rebuke escapes the calm lips of Nature. Silently as of old the great volume is spread out before us year by year. Quietly and lovingly, as at the first, her finger points us to the words, written in tender herb, and stately tree, and glowing flower; ever to our hearts repeating her simple admonition, "Look." She knows we shall obey her when the time is come.

But we are wandering from the subject. The law that the mechanical conditions under which they grow determine the form of living things, requires, like all laws, to be seen in its relations. It does not, of course, operate alone. The expanding germ is moulded into its shape by the resistance it meets; but the expansion has its own laws, and does not always take place equally in all directions. For the most part, in growing organisms, the tendency to growth exists more strongly in some parts than in others; and this varying tendency depends on causes which, though they are sometimes discoverable, are not always so. Let us revert to the case of the dorsal plates before referred to. If they are caused to rise up by the expansion of the germinal membrane within its unyielding capsule, it is evident that this

membrane must be growing chiefly in one direction (that at right angles to their length). It is the same in almost every case, but this one instance will suffice. Now this tendency to growth in particular directions is sometimes merely apparent, and arises from these being the directions in which there is least resistance to expansion. Sometimes, however, it seems to be due to a greater intensity, in certain parts, of the forces which produce growth; as, for instance, to a local *decomposition* generating a greater energy of vital action in that part, according to the law explained in the previous chapters. In these cases, the local growth resembles the increased development of plants on the side which receives most light. And the causes of the greater energy of growth in one part than another, may be often traced back several steps; as when an increased *pressure* produces a local decomposition, and this gives rise again to a new organising action.

Thus some apparent exceptions to the law of growth in the direction of least resistance receive an explanation. As, for example, that the root extends beneath the soil, and overcomes the resistance of the earth. The answer to this objection is, first, that the soft cellular condition of the growing

radicles forbids the idea that the roots force themselves into the ground; and secondly, that their growth is accounted for by the presence in the soil of the agencies which produce growth. In truth, the formation of the root affords a beautiful illustration of the law of least resistance, for it grows by insinuating itself, cell by cell, through the interstices of the soil, winding and twisting whithersoever the obstacles in its path determine, and growing there most, where the nutritive materials are added to it most abundantly. As we look on the roots of a mighty tree, it appears to us as if they had thrust themselves with giant violence into the solid earth. But it is not so; they were led on gently, cell added to cell, softly as the dews descended and the loosened earth made way. Once formed, indeed, they expand with an enormous power, and it is probable that this expansion of the roots already formed may crack the surrounding soil, and help to make the interstices into which the new rootlets grow. Nor is there any good reason for assuming that the roots encounter from the soil a greater resistance to their growth than the portions of the stem meet with from other causes. We must not forget the hard external covering of the parts ex-

posed to air and light. In some classes of palms this resistance is so great that the growth of the tree is stopped by it.

Similar to the case of the root are those in which mushrooms have been known to lift up heavy masses by their growth, sometimes raising in a single night a stone weighing many pounds. The forces which produce growth operate with enormous power. And well they may; for they are essentially the same forces—those arising from the chemical properties of bodies—which in our own hands produce the most powerful effects, and are often indeed so violent in their action as to be wholly beyond our control. But it is clear that such cases as this can offer no difficulty in respect to the laws of growth. Every one must see that the mushroom would certainly not have raised the stone if that had not been the direction in which its expansion was resisted least. In this respect, the case seems precisely similar to the expansion of steam in a boiler raising the piston. The mechanical resistance yields when the invisible inward force reaches a proportionate amount.

There is, however, another class of instances to which we must refer. These are the forms which

result not directly from growth but from decay, and of which the spongy pith of many plants is an example. The irregular cells and plates of which the pith consists are due to the drying up and shrinking of the pulp. In many animal structures this wasting process is accompanied by a contraction of the surrounding parts, and results in forms which can easily be traced to their causes.

CHAPTER V

THE LAW OF FORM.

THESE few instances, which might be indefinitely multiplied, may suffice to make it manifest that organic forms are to be ascribed to causes essentially the same as those which regulate the forms of inorganic bodies: in short, to the laws which force obeys wherever it is found. The peculiar structure which living bodies assume is due to the mechanical conditions under which they are placed, and not to a peculiar power operating to that special end. That peculiar power is, indeed, disproved, if further disproof were needed, by the existence of monstrosities and deformities, in which the end is not attained. The case is like that of the old doctrine that nature abhorred a vacuum. It was found that this was true only to a certain extent, and to varying degrees; just so does the special formative power supposed in living bodies produce peculiar forms only to a limited and varying degree of accuracy.

A word may be said here, also, respecting the

doctrine of "types," or standards, to which all living forms are referred. As a guide to the investigation of the organic world, this idea has proved itself invaluable; and the doctrine of corresponding parts in different organisms, to which it has been made subservient, constitutes, and must continue to constitute, a beautiful branch of physiological science.[1] But it is hardly necessary to say that no formative power is to be ascribed to those types or standards. The body needs some efficient cause to determine its form just as much, being conformed to such a type, as it would if it were not so conformed. Constancy of form proves constancy of conditions, and must do so equally upon every hypothesis.

But, in truth, neither general arguments, nor even an array of instances, are needed to give conclusiveness to the evidence that the forms of living bodies are mechanically determined. Startling as the proposition may seem when it is first uttered,[2] we no sooner clearly grasp the conception and see

[1] These corresponding parts are called "homologous"; as, for example, in plants, leaves and stamens are homologous; they correspond in their nature, although performing different offices.

[2] The surprise with which it affects us is similar to that which we feel, or might well feel, when we reflect that our sensations of light or colour, of music or of warmth, are referred to motion. The cause appears altogether inadequate to the effect. But we have in science to accept many such strange things as at least scientifically true.

what it means, than it becomes self-evident. It is, indeed, an axiom, and is capable of being expressed in the most simple terms. The phenomena of organisation are in this respect an instance of the necessary characters of motion. For it is the nature of motion that it takes the direction of least resistance. This is less a "law" of motion than a part of its definition. No law can be imposed on it, which can override this character; for that would be to alter the nature of motion itself: it would be to assert for it a self-directive power. In truth, the law of least resistance is involved in the very meaning of the words, for by "resistance" is meant that which, preventing, thereby directs the motion. So that, in fact, we may look at the question of organic form from another point of view, and obtain an assurance respecting the mode of its production which might be independent of experimental evidence.

For it is clear that organic forms are the result of motion. By this expression, indeed, nothing more is meant than that, as we consider form to depend upon the position of the particles of which any body consists, so, in the case of organic bodies, these particles must have assumed their various positions by moving into them. And since it is the nature of mo-

tion to take the direction of least resistance, it is equally clear that organic forms are the result of motion in the direction of least resistance. Which proposition, again, is only putting into a general formula the result to which observation has led us. In fact, here, as so often elsewhere, we first discover a truth in nature and then see that it is necessary.

Organic forms, like all natural forms whatever, must be the result of motion in the direction of least resistance. I am aware, however, that this may seem to be, though a true, yet a one-sided statement. For though motion cannot but take the direction of least resistance, yet it is determined, not only by the resistances it meets, but even more directly and decisively by the impulse which occasions it. Every motion has, at any given moment, an existing course, or arises from a force operating in a given direction; and the impulse of this force may be sufficient to carry it through, and cause it to overcome, great resistance, even though in other directions there may be less or none. The very use of a bullet or cannon-ball, for example, is to overcome resistance. But the deficiency in the form of the axiom when thus regarded is but apparent, and arises from our confining our view within too narrow a sphere:

when we take all the conditions into consideration, it appears to be sufficiently ample and exact.

It is true there is a certain direction possessed by every existing motion, or given to every motion at its origin; but we must remember that we may not arbitrarily fix our attention on any one point, and take that as a commencement. There is no origin, or first, in nature: it is to the intellect a chain without beginning as without end. Every point of time is in this respect like every other; nor when we tax our imagination to the utmost, can we approximate in the least degree nearer to the beginning than we are now. That divine act, to which all events are, by religious men, ascribed as their true cause, may be associated as well—quite as rationally and assuredly much more devoutly—with that part of the sequence which is present now, as with any we can conceive to have been in the past.

Whatever direction, therefore, any motion may possess at any time, it has been assumed under the same conditions as guide its subsequent course. The law that motion takes the direction of least resistance has prevailed from the first, and has given to it that direction in which we see it operate. The same may be said in respect to those impulses or

forces from which particular motions arise: these also have been determined by that very necessity of motion which they may appear to supersede. We see an instance of this in the bullet or cannon-ball, supposed before. The gun is an instrument for giving, by a definite resistance, a certain direction to motion. And so in every case; it only needs that we should not arbitrarily limit our thought, but should consent to carry our eye indefinitely back. Whatever we may suppose concerning the primary origination of motion, of every motion which we can perceive, or conceive, we must say that it is such as it is because motion takes the direction of least resistance.

And if every motion comes thus within the sphere of this law, so also, when it is rightly regarded, does the other fact referred to as apparently opposed to it—that of resistance being overcome by impulse. In this, too, there is only an apparent exception to the law of least resistance, and it arises likewise from an arbitrary limitation of our view. Giving the proposition its due extension, these cases are instances of the law, and not exceptions to it. For what is it that resists motion but force? and what is force but that which, if unresisted, produces

motion? It is, therefore, motion or the cause of it that is the true resistance to motion: as when the two hands are pressed together, each mutually resists the other. Thus we of course include the impulse of the moving body among the resistances to be considered, and the axiom assumes the utmost logical completeness. An opposing resistance deflects or changes motion, or is overcome by it, according as it is greater or less than the resistance to such change presented by the motion itself. For the force of that motion clearly becomes a resistance in relation to such change or deflection.

So much it has been necessary to say with respect to the general proposition, to make clear its bearing in respect to those obvious motions with which we can best deal in thought. The argument is precisely the same in respect to those minute motions of particles in which the growth of living bodies consists. Organic form, therefore, is the result of motion in the direction of least resistance: the proposition is absolute, and though first revealed by observation, is independent of it.

This general form of the proposition has the advantage of applying not only to the formation of living bodies, in so far as it is affected by conditions

arising within themselves, or by resistances immediately operative on them in their expansion; it is capable of including, when viewed in its wider aspects, all the external forces which are concerned in determining their forms. For all those forces have themselves arisen under the law of least resistance. In order to bring them within the same formula, we need only extend our thought and take into our regard a wider sphere. The resistances we have to consider are not only those which are immediately related to the growing organism, but those which exist throughout all nature. When we view the living thing in its cosmical, its world-wide relations, we may state in absolutely unlimited terms, that its form is determined by motion in the direction of the least resistance. That law has made it necessary, has carried it in its bosom from the first, and in due time has brought it forth.

Mr. Herbert Spencer, in his "First Principles," has done me the honour to refer to my arguments on this subject (as stated in the "British and Foreign Medico-Chirurgical Review," for October, 1858,) in terms of approbation. He urges, however, that the line of organic growth is rather the result of tractive and resistant forces combined than determined

by resistance alone. I may remark on this, that I did not design to ignore the operation of the former class of agencies. In the paper alluded to, I say: "The growth or expansion must exist before any question can arise of the direction it shall take; the molecular actions which result in organic increase must be presupposed. Now, these molecular actions come into operation under laws which are doubtless fixed and determinate, and which it may not be impossible to ascertain, but of which no account is attempted here. In the germinating seed, the vital action commences first, and exists most powerfully, in the radicle; the root, therefore, has the first tendency to grow. From this point the application of the law of living form commences. It is the more necessary to bear in mind this consideration, because it is of universal application. In almost all cases of growth or development, the vital action manifests itself in some parts rather than in others; it exhibits foci, as it were, of greatest energy. It is only by duly marking these, that the effect of mechanical conditions in determining form can be appreciated." And again: "If it should be remarked that there exist in developing structures certain definite modes or operations of force, such as attractions or repulsions

in particular directions, which serve to determine the form assumed, apart from any influence of visible mechanical conditions, this is willingly admitted to be true. The law suggested does not contravene, but rests upon these phenomena. They may be regarded in two ways: either as instances of those local manifestations of growth before referred to, and which are presupposed as the foundation on which the law is based; or, perhaps, more properly, they may be themselves considered as coming within its scope. In so far as these changes consist in the motion of particles, the law of least resistance may be asserted of them, or at least cannot be denied. Such molecular changes indeed form no part of the evidence on which the proposition can be based; inasmuch as the nature of the process and all its conditions are as yet beyond our investigation. But that in so far as they consist in motion, they conform to the nature of motion we may be quite sure. The *structure* of the germ must be such as to determine the operation of whatever chemical or other forces come into play within it, to produce motion in these particular directions."

I have thus sought to leave the door open to any other agencies, the operation of which in determin-

ing form it might be found necessary to recognise. But from the foregoing remarks, it will be seen that I believe there is another mode of regarding the subject, in which all these agencies may be viewed as instances of the law of least resistance, and by an extension of the sphere of vision become included among the very phenomena to which they appear as an exception. Under the one aspect the living structure is regarded by itself; in which case two, or more, laws are concerned in determining its form; under the other, it is viewed as a part, and in relation to the whole of external nature, and then all the forces affecting its structure come within one formula. It would be an error to look on these two modes of regarding the subject as opposed. Each is appropriate to its own object.

Several instances of the result of external forces in modifying the forms of plants and animals have been collected by Mr. Spencer.[1] The following is one of his examples:—

"If we examine a common fir-tree—and I choose a fir-tree, because the regularity in its mode of growth makes the law more than usually manifest

[1] In the "British and Foreign Medico-Chirurgical Review" for January, 1859.

—we shall find that the uppermost branches, which grew out of the leading shoot, have radially arranged branchlets (*i. e.* growing equally on all sides,) and each of them repeats on a smaller scale the type of the tree itself. But if we examine branches lower and lower down the tree, we find the vertically growing branchlets bear a less and less ratio to the horizontally growing ones. Shaded and confined by those above them, these eldest branches develop their offshoots in those directions where there are most space and light; becoming finally quite flattened and fan-shaped. The like general truth is readily traceable in other trees."

In this connection, it is impossible to omit a reference also to the beautiful experiments by which Mr. Rainey has demonstrated the operation of physical laws in the production of shell and bone. By causing the gradual formation of carbonate of lime in a viscid fluid, such as a solution of gum, that physiologist has succeeded in obtaining globules consisting partly of organic and partly of mineral matter, which correspond indistinguishably with the forms presented in the development of the shells or skeletons of certain animals.

It is remarkable, also, to how great an extent the

power of spontaneous repair of injuries resolves itself into an exhibition of the law of growth in the direction of least resistance. Is not a wound virtually an "axil"? and the granulations which form in it, or the new member which grows in the place of a lost one, do not they correspond to the buds which form in axils in the growth of plants, or the development of the embryo? The wound removes the resistance of the external investiture of the body. No special power, therefore, appears to be needed, by which a living body should be enabled to recover itself from accident or injury. The law of its formation involves also its repair. So, if the leaves of some plants be incised, buds spring up from the cut surface; or a new hydra grows from a wound in its parent: an artificial axil being made. Other circumstances, doubtless, are concerned in repair; but the general fact is a simple exhibition of the mechanical direction of growth. The new material is accumulated where the resistance to expansion is removed:—is it not deposited there rather than in other portions of the body, because the resistance at that point is the least? We know that repair is effected at the expense of the general nutrition of the body: and we know, too, the effect of pressure

in limiting it. At least we may say this: that if this law of growth be true, then it is certain (other circumstances being the same) that wounds must be repaired.

Dr. Macvicar has adduced very striking arguments to show that the natural forces, regarded in their most general aspect, tend to the production of the sphere—the most perfect form—and that the phenomena of organic development are, to a very large extent, interpretable from this point of view. "It is precisely those forms which geometry shows to be most highly endowed, that natural bodies tend to emulate in their forms, as they themselves become more perfect, the physical forces in their various modes of operation constituting a machinery framed expressly to realize these forms." [1] He refers to the counteracting yet co-operating effects of gravity and of heat, drawing or expanding matter alike into spherical forms; and points out how living bodies, almost without exception, consist of cells which are spherical, except where changed by pressure; and how all organic forms exhibit a spherical tendency more or less modified by interfering

[1] "The Economy of Nature; or, First Lines of Science Simplified." Appendix, p. 108.

causes. But we could not do justice to his arguments without quoting all his words; and, indeed, without going further, may we not sum up the lesson of these various investigations in the words of the great American physiologist, Dr. J. W. Draper:—"The problems of organisation are not to be solved by empirical schemes; they require the patient application of all the aids that can be furnished by all other branches of human knowledge, and even then the solution comes tardily. Yet there is no cause for us to adopt those quick but visionary speculations, or to despair of giving the true explanation of all physiological facts. Since it is given us to know our own existence, and be conscious of our own individuality, we may rest assured that we have, what is in reality a far less wonderful power, the capacity of comprehending all the conditions of our life. Then, and not till then, will man be a perfect monument of the wisdom and power of his Maker, a created being knowing his own existence, and capable of explaining it."

CHAPTER VI

IS LIFE UNIVERSAL?

"MAN capable of explaining his own existence!" I seem to hear the reader exclaim, as he peruses the eloquent passage borrowed from Dr. Draper, in our last chapter; "it is a vain dream; we shall never be able to say what life is." Perhaps not; yet we should not be too hasty in deciding on this negative. Nothing can seem more improbable, as that question has been put, than that it should ever receive a satisfactory reply; but may there not have been an error in the way of putting it? Problems that are truly simple sometimes come before us in a very difficult form, owing to pre-conceptions in our minds, and demand for their solution not great ingenuity or power, but that we should disembarrass ourselves of false persuasions. One of the greatest intellects has left on record the maxim—it is part of the rich legacy bequeathed by the author of the *Novum Organum*—that "a wise seeking is the half of knowledge." According to our first impression, a wide gulf separates that which has life from that which

has not. We naturally, therefore, prejudge the very point at issue, and assume in living things the possession of a peculiar endowment, which is the cause of all that is distinctive in them. And then, with this idea in our minds, we strive in vain to untie the knot. The more we seek to understand life, considered as a power capable in itself of effecting the various results which are exhibited in organic bodies —their growth, development and repair, their form and structure, their continued existence in spite of opposing agencies, their power of assimilating extraneous substances and making them part of themselves—the more convinced we become that it can never be understood.

And the difficulty is immensely increased by the connection which exists between life and *consciousness*. The union of mind and body is in our experience so intimate and so incessant, that we naturally think of them together. Hence it arises that quite foreign considerations, affecting the spiritual nature of man, ever tend to exert a disturbing influence on the higher questions of physiology. It is not easy to keep separate in our thoughts the purely physical life of the body, and the spiritual faculties of feeling and will to which it is subservient.

But distinguishing the mental and the material life, and fixing our thoughts upon the body, we may see the path to be pursued. Life exhibits, not the agency of a single power, but the united effects of several causes: the problem of vitality requires division into various simpler problems. We have to seek not the nature of an invisible agent, but the demonstrable causes of a vast variety of physical results. We have found, for example, three prominent questions claim an answer in respect to the living body: how it acts; why it grows; and whence its form. Taking these questions one by one, and seeking guidance from the facts presented to us by nature, we have also found that each of them was capable of a solution simple enough, and even obvious when once it was seen. We may briefly recapitulate the results at which we have arrived.

I. Living bodies GROW by the operation of chemical force, which exhibits in them a twofold action, and produces substances which tend to decompose; on the same principle that gravitation in a fountain causes water to rise by the effect of its fall. So chemical change, or decomposition, causes the nourishment of the body, and the two opposite processes

of growth and decay proceed in mutual dependence. This law is easily understood by fixing the thoughts on any case in which an action of one kind produces another that is opposite to itself; the movement of a pendulum, for example, in which the downward motion produces the upward, and the upward furnishes the conditions under which the downward can again take place. It is thus chemical action produces the vital action; and the vital action furnishes the conditions under which the chemical action can again take place. Living bodies, then, grow through decay, or through chemical processes which are equivalent to decay, and which resemble it in producing force.

II. The body, thus growing, receives its FORM or structure from the conditions under which it is placed in its development. Under the influence of the forces which are operating upon it, and which excite its growth, the germ expands (for the most part in certain directions more powerfully than in others); and by the varying resistances it meets in this expansion, is moulded into its specific form.

III. This form adapts it to its FUNCTIONS. The body tends to decompose, or to undergo chemical

changes which give rise to force. The absorption of power in nutrition, and the evolution of it again in the decomposition of the tissues (the muscles, brain, &c.,) "is precisely analogous to that which takes place in forcibly separating the poles of two magnets, retaining them apart for a certain time, and suffering them to return by their attractive force to their former union. The energy developed in the approach of the magnets towards each other is exactly equal to the force expended in their separation." In the case of the living body, the force thus developed within it necessarily produces the actions to which its structure is adapted.

Thus, for example, when a seed is placed in the ground, the first process which takes place within it is one of decomposition. The mass of the seed consists of starch and albumen, in the midst of which is placed a small cellular body, called the germ. This germ will grow, and develop into the future plant, but only on condition that a process of decay goes on in the starchy and albuminous matter with which it is in connection. Part of the latter sinks into the inorganic state, uniting with oxygen, and passing off as carbonic acid. The young plant is at first of less weight than the

seed or root which has disappeared in generating it.

When it arrives at the surface of the soil, a new process commences. The rays of the sun, falling on its leaves, maintain in them a continuance of the same process (one of chemical change) by which the first development of the germ was determined. Thus new materials are added to the plant, the light exciting those chemical processes which produce the organic arrangement of fresh portions of matter. The leaves, under the stimulus of the sun's rays, decompose carbonic acid, giving off part of the oxygen, and "fix," as it is said, the carbon in union with hydrogen, and sometimes with nitrogen, &c., to form the various vegetable cells and their contents. It is curious that the oxygen and the hydrogen, thus united with the carbon, are very often in the same proportion in which they unite to form water. Starch and sugar, for example, both consists of carbon and (the elements of) water.

An animal now consumes this plant. In its digestion there takes place again a precisely similar process to that with which we started—the germination of the seed. The substance of the plant partially decomposes within the stomach; a portion of it sinks into a state approximating to the inorganic, while

another portion (doubtless, by means of the force thus generated) becomes more highly vitalised, and fitted to form part of the animal structure. The germination of the seed, and animal digestion, are parallel processes. Each of them is twofold—a decomposing and a vitalising action going on together, the latter having its origin and depending upon the former.

Having formed part of the animal structure for a time, this living matter decomposes yet again, and again gives off its force. But now, instead of effecting, as in the previous cases, a vitalising action, the force produces a mechanical action in the muscles, or a nervous action in the brain, or, in short, the *function* of whatever organ the matter we are tracing may have been incorporated with;—the function being but another mode of operation of the same force which caused the nutrition.

And thus, supposing the action to have been a muscular exertion, say the lifting of a weight, we shall have traced the force, which came from the inorganic world at first in the form of the sun's rays, and was embodied in the substance of the plant, back again into the inorganic world in the form of motion.

Let us observe another thing. In previous chapters the function and the nutrition of the body have been distinguished from each other, and even contrasted.[1] They are opposites:—the one is the formation of the body, the other depends on its destruction. And for either to be understood, it is necessary that the distinction between them should be clearly apprehended. But when we take a larger view, the relation of these two processes assumes quite a different aspect. The appearance of opposition is merged in a wider unity. The nutrition and the function of a living body are rather a twofold presentation of one process, than two different processes. That which, seen on one side, is nutrition, seen on the other is function. Let us take, first, the case in which a decomposition within the body, itself produces an increased nutrition. Here, it is evident, the increased vitality is the equivalent of a force that, if directed through the muscles, might have been productive of motion. It is, in fact, an internal function, so to speak. The force set free by decomposition in the body, instead of operating ex-

[1] To guard against misapprehension, it is as well to say that by the term *nutrition* are not intended any of the actions connected with the taking of food, but only those minute internal changes by which the growth and repair of the body are affected.

ternally, operates within it. Nutrition, though it is the basis and provision for the external functional activity, may itself be classed as a function, and may take rank in the same list with the other results of internal decomposition—motion, animal heat, &c. The case is the same as when, in a chronometer, part of the force of the unbending spring is employed to bend a secondary one.

But in another respect, also, nutrition may be seen to be identical with function. The very same process which is the function of one body, is the nutrition of another. The vegetable world, in so far as it serves for food, has for its "function," in the strictest sense, the nutrition of the animal. This is the result which it effects by its regulated decomposition. The animal instinct provides the conditions under which the function of the vegetable is performed. The plant yields up its life to nourish the animal body, as that body, so nourished, in its activity yields up *its* life to impart force to the world around.

And this is but an illustration of a law which has its basis in the very nature of force itself. Every giving off of force has for its necessary effect the

storing up of force in equal amount elsewhere. The two halves of this process cannot be divided. And whichever half of it we may be at any time regarding—whether the storing up of force (which answers to nutrition), or the giving it off (which answers to function)—we may be sure that the other is also present. That which is to one thing the storing up of force, must be the giving off of force to another. We shall perceive it as either, according to the view we are taking at the time. The storing up of force within the animal frame usurps to itself, especially, the name of nutrition, because our regard naturally centres upon ourselves and upon that which is most kindred to us.

But it might be that beings, different from ourselves, should look upon the other side of this process, and see in the animal nutrition rather a loss than a gain of force—a dying rather than a coming into life. Nature in this respect is like the books of a commercial firm. When there is no change in the total, however the various amounts may be shifted, there is necessarily always an equal loss and gain, and each change will be regarded as one or the other according to the interests affected.

Surely it is but fair that we should recognise this rigid equity, and try to look upon ourselves, sometimes, as if through alien eyes. We are but borrowers from Nature's store, and what she showers on us with open hand, with a stern clutch she snatches from our fellows. But we are honest debtors, and pay to the last farthing.

Besides the three points to which we have directed our attention, there are very many other questions which living bodies suggest, and which equally deserve inquiry—the causes, for example, of the difference between the animal and the vegetable, or between the various textures of which our own bodies consist; by what physical necessity bone is formed in one part, muscle in another, and nerve in a third: why the circulating fluid of plants, as a rule, contains *green* particles, and that of animals *red* ones, these being complementary colours, which together constitute white light: how the various changes which take place in the gradual development of the organism, from childhood to adult life, are effected, and to what deep principle of universal order they conform. These and innumerable other subjects, which physiology presents on every hand, claim, and doubtless would well repay our pains.

But looking only to the conclusions indicated above, do they not advance us a step towards a better understanding of the living body? Do they not, at least, enable us to perceive that the main phenomena which it presents, are examples of the same laws and properties with which our experience of other things makes us familiar? In other words, do not we see that organic life is not a new thing, as compared with that which is met with in the inorganic world, but a new form of the same things? The same forces operate, the same laws rule, in the cases of organic and inorganic structures; the results are so different because the conditions differ. It has been suggested before that the animal body, in respect to its power of acting, presents an analogy to a machine; and the idea seems capable of receiving a still wider application. What is a machine but a peculiar method of applying common forces and universal laws? We perceive this at once if we consider any particular case. In making and using a machine, we add nothing and we alter nothing, in respect to the nature and properties of things. We do but use for a particular end the powers which exist around us, and the laws which are universally operative. Nay, so far is a machine

from involving new forces, or new laws, it is precisely by virtue of the unaltering laws and force of nature, that it can be constructed and kept in operation. As a machine, it is dependent upon, and an example of, the laws which prevail without it; if they ceased or changed their operation, its adaptation and its power were lost. The case is the same with the living body. This also is dependent on, and is an example of, the laws and forces which prevail without it. If the laws of inorganic nature changed or ceased, if the forces of inorganic nature were no longer what they are, the animal structure would be of use, it would even exist, no more. The organic world does not differ from the inorganic in its essence.

But it differs. It would be a fatal error—happily it is an impossible one—to confound the two. There is a difference in the mode of operation though the elements are the same. The physical powers have received in the organic world a particular direction, and are made to work to certain results which are attainable only through living structures.

Surely here, then, we are in possession, up to a certain point, of a clear and definite answer to the

question, What is Life? Ever remembering that we speak of the bodily life only, may we not reply: It is a particular mode of operation of the natural forces and laws? We can trace the force operative in life, to and fro, between organic and inorganic bodies; we can see that in the organic world the laws we know in the inorganic are still supreme. But the results are new.

Thus, it is easy to understand how there has arisen the conception of a peculiar vital Entity, or Principle. This was a rapid generalisation before the working of the various forces that conspire in life had been discerned. For the peculiar results, a peculiar agent was supposed, instead of a peculiar mode of operation. Not that this conception has been universal. Individual men have urged reasons in favour of a different view, at various times. One of the most notable instances is that of Coleridge, who, in his *Essay towards the Formation of a more Comprehensive Theory of Life* (though giving utterance to some opinions which are doubtful or obscure,) seems to have anticipated, so far as his general view is concerned, almost the entire advance of physiological knowledge since his day.

His idea (derived, it is said, originally from

Schelling) is, that physical life is a process, or a mode of operation, of the same powers which we recognise under other names, as magnetism, electricity, or chemical affinity. These, by their own properties, effect all the results observed in life, but they are grouped in a special way, the various forms of action being so united as to constitute, out of many parts, a mutually dependent whole. The distinctive character of living things is the exhibition in them of a "principle of individuation," which constitutes them units, separated from, while yet partakers in, that which is around them. "Life," he says, "supposes an universal principle in nature with a limiting power in every particular animal, constantly acting to individualise, and, as it were, figure the former. Thus, life is not a thing, but an act and process." And tracing the chain of organic being upward through its various grades, he points out how the great characteristic of advancing elevation in the scale of life, consists in the ever more perfect individualisation of the creature; its being marked off from the rest of nature, and placed in an attitude of freedom to use and subordinate her powers.

But this subordination is not effected by the

superaddition of a new power in living things. The subjection of the physical to the vital forces resembles rather a voluntary self-control than a coercion from without. The power on each side is the same. Does not the following passage from Coleridge, indeed, convey an argument that finally disposes of the idea that the force of organic bodies can be essentially different from that of the surrounding world; that being the very force which they live by assimilating or drawing into themselves?—

"To a reflecting mind the very fact, that the powers peculiar to life in living animals, include coherence, elasticity, &c. (or, in the words of a recent publication 'that living matter exhibits these physical properties') would demonstrate, that in the truth of things they are of the same kind, and that both classes are but degrees, and different dignities of one and the same tendency. For the latter are not subjected to the former as a lever or walking-stick to the muscles: the more intense the life is, the less does elasticity, for instance, appear as elasticity: it sinks down into the nearest approach to its physical form by a series of degrees, from the contraction and elongation of the irritable

muscle, to the physical hardness of the insensitive nail. The lower powers are assimilated, not merely employed, and assimilation supposes the like nature of the thing assimilated; else it is a miracle; only not the same as that of creation, because it would imply that additional and equal miracle of annihilation. In short, all the impossibilities which the acutest of the Reformed divines have detected in the hypothesis of transubstantiation would apply in the very same words to that of assimilation, if the objects and the agents were really of unlike kinds. Unless, therefore, a thing can exhibit properties which do not belong to it, the very admission that living matter exhibits physical properties includes the further admission, that those physical or dead properties are themselves vital in essence, really distinct, but in appearance only different, or in absolute contrast with each other."

The term "Principle of Individuation" admirably expresses the distinguishing characteristic of the animal body. The force it contains is, as it were, reflected within itself. Gathered from nature in nutrition, the force which the organic matter embodies, instead of passing freely onwards, is re-

tained and stored up within it; and the structure into which the growing organism is moulded, causes that force, when it is set free, to effect actions which subserve the well-being of the animal. And not only so, but this very force, when it is given off, by decomposition, within the body, may be reflected back upon the organism itself, and cause its increased growth; the decay, as we have seen, renewing the nutrition. Is there any way of expressing these facts more appropriate than to say that in the animal body the force is turned upon itself—self-centered? It is "individualised," limited within definitely marked bounds. Nothing is there which is not elsewhere in nature, but a limit is applied to that which elsewhere is freely circulating.

Again it is like a machine. We cannot help perceiving the analogy; for in a machine the very same thing is done. The forces which are freely circulating through material things are seized by man, and *limited*. They are bound up, and retained, to be used for certain purposes alone. A "principle of individuation" is brought into play; and an instrument, or "organ," is the result. "Individuate" the forces of nature, and we have an instrument.

The chief of instruments, the living body, presented ready to each one of us to preserve and use, is constituted thus.

It adds greatly to the interest with which the animal creation may be contemplated, to look upon it with this thought in our minds. To feel the subtle links that tie together the diverse forms of Nature's energy, and recognise, in the sportive youth or vigorous maturity of bird and beast, tokens of the same powers that make firm the earth beneath their tread, give fluency to the waves, and cunningest chemistry to the all-embracing, all-purifying air, opens to the lover of the animated tribes a new delight. Not aliens are they to the earth on which they dwell, not strangers seeking temporary lodgment and convenience, but in truest sense earth's children, with the child's claim to shelter in the bosom which sustains them all. Bone of her bone, flesh of her flesh, breath of her breath. Each thrilling wave of life flows warm and fresh, from fountains which the sunbeams feed, which roll through every fibre of the solid globe, and spring up glowing from the central fires.

We do not require, for organic life, to assume any new or special power; the common and all-

pervading powers of Nature are enough. But now a question arises: How can the living be derived from that which is not living? How can any limiting, or directing, or adapting, make life to be where life was not? This is a legitimate question. Men refuse to rest satisfied with any supposition which seems to refer life to an unliving source, or to reduce it to the play of mere mechanic forces. Often have the instincts of our nature repudiated the resolution of vital phenomena into the shifting balance of attractions, the aimless afinities whose sweep is bounded by the chemist's crucible. And the feeling has a just foundation; organic life cannot spring merely from dead matter. But if the demand for a living source of life is just, it is to be observed that this demand can be satisfied in two ways:—Either the material world is dead and life does not spring from it; or, *if life springs from it, then it is not dead.* If it be proved that the forces and laws of the inorganic world constitute all that is to be found of physical power or principle in organic life, then does not the conclusion follow that the apparently inorganic world is truly living too?

This is no parodox. It is far from being a nov-

elty. That Nature is universally living is a position that has often been maintained; but evidence of its truth could not be given until various physiological problems had been at least approximately solved. Let us first conceive the case hypothetically. That which constitutes matter living, in the ordinary sense, is a certain arrangement of its elements, in relations opposed, more or less, to their chemical tendencies. This arrangement of the elements gives rise to a substance in which there exists a tendency to decompose—the organic substance. This substance, moulded into adapted structures, constitutes an organic body. The conditions essential to organic life are, then, these two: an opposition to chemical affinity in the arrangement of the elements, and a structure adapted to the performance of the necessary functions. Now we must, in the present state of our knowledge, consider the living body, like all other material substances, to consist of "atoms"—minute particles, beyond which we cannot conceive division to be carried. These atoms, by their arrangement, constitute the organic matter; and if we reflect, we see that they themselves, separately considered, are not organic. They are simply the materials out of

which the living body is built up, and are the same in the most highly organised animal as in the simplest mineral. The ultimate atoms of oxygen and hydrogen, for example, are the same in the human brain as they are in water; the living substance is necessarily made up of particles which are not themselves living. In other words, physical life is a living relation of unliving parts. The ultimate atoms of which a living body is composed are not individually possessors of life; the life is in their mutual connection.

This form of life, which depends upon an opposition to chemical affinity, and therefore rests upon that affinity in its basis and condition, is peculiar to animal and vegetable bodies, and may be called, for the sake of distinction, "organic life." In this kind of life it is evident that any forms of matter which are constituted according to the laws of chemical affinity, do not partake. Such are the mass of our own globe, and in all probability the other bodies known to us as the stars and planets. These are not partakers of the life which we have called organic.

But if we think of Nature on a larger scale, we remember that there is another property, or tend-

ency of matter, cognate to chemical affinity, but affecting masses as well as atoms. Why should not *gravity* afford the conditions necessary for an organic relation of the masses of which the universe consists? We know there also exists a force opposed to gravity, which produces an arrangement of the heavenly bodies in relations different from that in which gravity tends to place them. Why should not this force constitute, in respect to them, a true analogue of the vital force? It has been suggested that the distances of the stars from each other are probably not greater, in proportion, than those which separate the particles of what we call solid matter, and that the stellar universe might present, to senses of proportionate scope, an appearance like that which solids present to us. A group of stars may thus be regarded as constituting a substance—why not a vital substance? We certainly know it to be full of the intensest activities, and to be the seat, especially, of two counteracting forces. Why should not this "substance" be moulded, also, into truly vital forms? In short, why should not the multitude of stars constitute one or more living wholes? Would they not thus present to us a strict parallel to the "living wholes"

which we have long recognised to be such—unliving particles in living relations to each other? True, the earth we live on is inorganic: true, we have good reason to conclude all the orbs contained in space to be inorganic too. This is no reason that they are not "particles"—atoms—though inorganic by themselves, in an organisation of a corresponding magnitude. The atoms of which our own bodies consist, also, are "inorganic by themselves."

"An organisation," I said, "of corresponding magnitude." I am not the first to use the term. The "organisation" of the heavens—of our own solar system, and of the various galaxies of stars—has been often spoken of. The likeness of the stellar groups, and of their ordered and recurrent movements, to the forms and processes of the organic world, has found for itself a voice, at least in metaphor. There is a striking passage in the first volume of "Cosmos" bearing so directly on this view, that though it will probably have presented itself to the reader's mind, he may thank me for reproducing it. "If we imagine, as in a vision of fancy, the acuteness of our senses preternaturally sharpened even to the extreme limit of telescopic vision, and incidents which are separated by vast in-

tervals of time compressed into a day or an hour, everything like rest in spacial existence will forthwith disappear. We shall find the innumerable hosts of the fixed stars commoved in groups in different directions; nebulæ drawing hither and thither like cosmic clouds; our milky way breaking up in particular parts, and its veil rent. Motion in every point of the vault of Heaven, as on the surface of the earth, as in the germinating, leaf-pushing, flower-unfolding organisms of its vegetable covering. The celebrated Spanish botanist, Cavanilles, first conceived the thought of 'seeing grass grow' by setting the horizontal thread of a micrometer, attached to a powerful telescope, at one time upon the tip of the shoot of a bamboo, at another upon that of a fast-growing American aloe (*Agave Americana*,) precisely as the astronomer brings a culminating star upon the cross-wires of his instrument.[1] In the aggregate life of Nature, or-

[1] The absurd introduction of the word "telescope" in this sentence has been left but was probably due to a slip of Hinton's in failing to correct a printer's error. In Otté's translation of Alexander von Humboldt's "Cosmos" Vol. I, p. 140) it is stated that the micrometer was attached to a powerful microscope. Nowadays, following up the pioneering observations of the Spanish botanist, it is easily possible to record for representation on the cinematic screen the fascinating spectacle of a growing plant, admirably illustrating the tendencies that Hinton here expounds. (Ed.)

ganic as well as sidereal, Being, Maintaining, and Becoming, are alike associated with motion."

Here we will pause, and abstain from argument. Let the thought stand as a suggestion merely, a whim of fantasy. It is at least a noble and elevating one. The dissevered unity of nature is restored. The lower rises to the higher rank; the higher wins a new glory in descending to the lower place. Unbroken stands the scheme before us. Life infinite and boundless; throbbing in our veins with a tiny thrill of the vast pulse that courses through the infinitude of space. The joy and sorrow in our hearts calling us to an universal sympathy, guaranteeing to us a sympathy that is universal in return.

The subjects we have discussed might almost be regarded as riddles, presented to us by a Higher Intelligence, in order to cultivate the powers that are exercised in solving them. Nor can this thought be otherwise than welcome to us. Surely man is but a child. I am "an infant crying in the night," says the poet, and the words find an echo in all hearts, because they are true of all humanity. Man is a

little child, and as a little child he is taught. His feeble powers are drawn gently out, in tender sportive ways. Lord Bacon says, in words which prove in him a sensibility of heart as exquisite as the reach of his intellect was sublime: "Of the sciences which contemplate nature, the sacred philosopher pronounces, 'It is the glory of God to conceal a thing: but the glory of the king to search it out': not otherwise than if the Divine Nature delighted in the innocent and kindly play of children, who hide themselves in order that they may be found, and in His indulgent goodness towards mankind, had chosen for His playfellow the human soul." Nature sports with us, presenting to us easy questions in hard ways. She gives us riddles—the fact simple, the mode in which it is put before us complicated and involved. We think in wrong ways, before we find the right; but in the meantime our faculties are strengthened and enlarged. Our chief difficulty in comprehending Nature is her simplicity, the multitude and boundless variety of results which she educes from one law, and this law, it may be, self-evident and impossible not to be. We cannot, till we have learnt by long experience, un-

derstand what great events from simple causes spring, nor how truly "the workmanship of God is such that He doth hang the greatest weight upon the smallest wires."

How amazing it is to trace the wonderful processes of life, even so partially and feebly as we have done, to the simplest laws of force. And yet more amazing is it, to reflect that these same laws extend illimitably over the field of Nature. If they bear such fruit in one least corner of the universe—for "if a man meditate upon the universal frame of nature, what is the earth but a little heap of dust?" —in what rich harvests of order, beauty, life, may they not issue, through all the immeasurable sphere of their dominion! Before the resources of creative power, imagination stands silent and appalled.

The study of Nature, revealing to us, though faintly, yet truly, traces of the laws and methods of the Highest and Universal Worker—revealing to us, in His work, an absolute singleness of aim and unity of means, perfectness of calm repose one with unfailing energy of action—this study has its worthy end, only when it raises us to act like Him: with steadfast and single aim which no passion can

pervert, nor interest corrupt; with means which, ever changing, are yet ever one in changeless rectitude; with an activity untiring, and a calmness that cannot be disturbed, rooted in love and trust.

CHAPTER VII

THE LIVING WORLD.

THIS course of thought became the starting point, in my own mind, of a further train of reflections, which took a wider sweep, and which seem to me to conduct to results of great importance. Let me beg the reader to accompany me a short distance in pursuing it. If our former arguments are sound, the result at which we arrive is this—that not only are the organic and inorganic worlds, which seem to be so different, truly one, exhibiting the same forces, powers, and laws; but life itself, or that which we have called so, appears as a mere result of chemical and mechanical agencies, into the effects of which its most distinctive phenomena are resolved. We find no special power which we can call by that name. May it not, then, be urged that we have grasped at life, and it has escaped us? Those processes which we find in its place are not what we sought—are not what we can recognise. Life on this view is not explained; it is denied. It is true that it is made universal, but in that very

universality the thing itself is lost. The passive processes which are substituted for it present not one of the characters which we seem to feel and know in life—fulfil not one of our instinctive affirmations respecting it. Have we not analysed it into nonentity?—found the fair seeming fruit to be but ashes?

In a certain sense I feel that this is true. By life we do not mean, and we cannot accept as its explanation, any mere results of material laws. Our souls may be over-ridden by demonstrations to this effect, silenced by evidence to which we may not deny assent, but they are not satisfied. There is another life than an aggregate of material processes: whatever may be the appearance, *that* cannot be the truth. Life is a unity, not a group of results; a power, not a mere effect.

These thoughts, and others to which I shall refer presently, worked in my mind. I could not be blind to what seemed to me plain and indubitable facts—facts which showed that the most characteristic phenomena ascribed to life had their source in chemical activities and mechanical conditions. I could not wish to be blind to them; for they seemed to me to possess an exquisite beauty, and to give

an invaluable simplicity and definiteness to our conceptions. They seemed right, true, delightful; yet there was in them something that was not right. They made Nature less, or seemed to make it so.

And this also one could not but feel:—How should it be that the investigation of life, above all other studies, should have such an insidious tendency to conduct results which the heart repudiates? Why should that study especially, though pursued with the best aims and hopes, lead us, alike unwittingly and unwillingly, to results which seemed, at least to some, hostile to religion, threatening to man's best hopes? Why was our enthusiastic pursuit of those glimmerings of light which it were false to our Maker not to pursue, our glad grasp of some clear signs of order and necessity in this dark-seeming corner of Nature, destined to lead us to mere blank and void? Surely there must have been some misapprehension here—some latent false thought, the effects of which were thus made manifest.

Nor, indeed, were these feelings long in finding satisfaction. Through the fresh light which I had gained respecting Life, my eyes were opened to perceive the meaning of some other facts, which until

then had possessed for me but little significance. In common with the rest of thinking people, I had often heard the doctrine stated that we know only phenomena.[1] I had considered more or less the grounds on which this was affirmed, and I suppose that the passive condition of my mind in respect to it represented pretty well that of the majority of men. But when I obtained these views of Life, this doctrine rose from a mere speculation into a practical truth. It became a new possession to me; for I could not but recognise in it the key to the strife in which I found myself engaged. If those things which we call the physical world—the substances and forces with which Science deals—are but phenomenal (that is, if they are but appearances of some existence which we thus perceive not as it is,) then the reducing of physical life to the results of chemical and mechanical processes no more disappoints the intellect, or makes a discord in the soul.

Life is not thereby banished from the world: it is but shown to have its seat in that which is not phenomenal. It is a living world which we thus per-

[1] For the proofs on which this doctrine is based, reference may be made to the writings of Sir W. Hamilton; or especially to the able summary in Mr. H. Spencer's "First Principles."

ceive under the appearance of passive forces; of chemistry and mechanism. The authority of our native instincts, the trustworthiness of our deepest feelings, are still maintained; they are restored with fuller sway. Of the two results that seem to follow from the scientific investigation of life—the universality of its presence, and its resolution into dead mechanic force—the former remains a truth, the latter is but an appearance. Life *is* universal: it only *seems* to be mechanical.

See! we give up, at the call of truth, what we desire and love; and in the end we receive it back, increased a thousandfold. Laid in the ground and *dying*, the seed bears much fruit.

I say, the authority of our instincts and emotions with respect to Life is restored, and more than restored. They rise into a liberty which could hardly have been conceived before; for, in truth, investigation into the laws of the material world, and the discovery of the undisturbed dominion of those laws in the organic kingdom, is but the casting off of the shackles which constrain and bind them down. We cannot think worthily of Life, until we see that it is not in these physical things at all, which possess but the shadows and appearances of it; till we carry

our thoughts beyond. For which deliverance the needful condition is that our limited thought of Life, as an agent having its seat alone in the few poor things that we call living, should be wholly set aside.

There is no such life as that which thus there seems. There cannot be. The conception of such an acting or regulating power in the physical world carries a contradiction in itself. The physical is the sphere of passive results; its order is a mere sequence of effects; as being phenomenal, indeed, it is necessarily so. Life is more than that fancied power embodied in organic things; or there is none. And the problem which we have to answer is plain: it is to find *that* Life, of which the seeming life in the organic world, the seeming deadness in the inorganic, alike are the appearance.

Now, perhaps, it is true that this question cannot receive an answer from the intellect alone; but there is no reason we should limit ourselves to the intellect in the attempt to answer it. For the emotional part of our nature also has its claims; it puts in demands we cannot refuse to listen to, and is capable of furnishing aid to our thoughts. No conception of nature which does violence to the emo-

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tions can be accepted as true. The facts presented to us, indeed, include an element—that of visible use and subservience to happiness and affection—which appeals directly to the emotions, and can be apprehended only by them. To attempt the solution of the problem here presented to us, by the intellect alone, is to employ upon it only a portion of those powers of our nature that are directly appealed to. To omit the moral feelings, the emotions of the heart, were as much against reason as to leave out the senses. These feelings, as well as sense and intellect, must have their part in the interpretation of the facts of nature; for these are presented not to one part of us only, but to the whole. On one side the senses are appealed to by direct impressions; on another the intellect, by relations of order and necessity not less truly obvious, though perceived in a different way; and on yet another side, the emotions are appealed to by relations of good and evil, of delight or pain, approbation or abhorrence, not one whit less clear or real, though perceived in still another mode. And indeed the question that now comes before us is one that appeals especially to the emotional part of our being. For the demands of intellect and sense unite in giving us the views

we have discussed before; they present to us this phenomenon: this uniform process of mechanical connection is that which appears to them. Our question is—what is it which thus appears, when, in science, intellect thus unites with sense, and these two portions of our nature, without the third, give *their* apprehension of the world? How read yet again this still partial and inadequate perception; necessarily partial and inadequate, because not including the use of all our powers? The moral emotions now must have their part, else but a fragment of us usurps our voice.

And being set free by the knowledge that the physical world with all its laws and forces is but an appearance, how perfectly adapted these emotions show themselves for the work on which we demand their service. To picture to ourselves this very Life, and truly apprehend the living world which appears to us under these mechanic forms, this is what we need their aid to do. It is a world that must surpass in depth and fulness this world of mere phenomena: a world in which Life truly dwells, as it does not in this; a world of action, in the true sense of the term, as this is not; a world of

perfect order, which the beautiful (yet, alas! how often cold and cruel) passive order of this world reflects: and we have hearts and souls to know it by.

What is it that appears to us under the phenomena which we know as those of Life, regarded at once in their results and in their law? This is the question we must ask. We find it easy to invent an imaginary power, such as "the vital principle," which might (as we suppose) effect all the marvellous results of use and adaptation in the organic world, itself being exempted from the dominion of the common laws, and operating simply to those ends. But our true problem is a higher one than this, and admits not of such hasty answer. It taxes more than the imagination, and cannot be met by words which express no meaning. For it is nothing less than this: what is the true significance of that law, which, appearing to us under the simple form that motion takes the direction of least resistance (a mere definition, mere truism as it is,) yet brings forth the varied order, the beauty and adaptations, the ends and uses full of manifest love, which the animated world reveals? What is this

law of least resistance—of seeming physical necessity—which bears such fruits? What fact is it that shines through this "phenomenon"?

In order to feel the question aright, we need to retain both terms of the problem well in our thoughts. There are the *results* of life, in its uses, on the one hand; there is the necessary law embodied in its material processes on the other. The true thought of life must account for not only one, but both. In life there is a necessity which seems mechanical; there is a result which is divine. How shall we read this riddle?

I had not long pondered this problem, when I felt that it raised itself out of the intellectual into the moral sphere; and that, in truth, it was a spiritual fact that thus presented itself to us under a material guise. Translated from its passive phenomenal form into the terms of true action, this law of least resistance assumes a moral meaning: it expresses rightness—love. It is adapted, thus, to bear the fruits we see it yield.

In dealing thus with Life, holding it with both hands, as it were, looking at it on both its sides—its laws and its results—and so binding ourselves by the true conditions of the problem; and re-

membering also that Nature is not truly what it is to our apprehensions, but is something more; we are forced to feel that the phenomena of organic life put us in the presence of a spiritual fact. And since in that life there is nothing more than is throughout all Nature, Nature itself must be the phenomenon —or appearance—of the spiritual world.

To this point I was brought, and feel myself still inevitably brought, by the studies to which the science of physiology committed me. If there be any life in Nature—and how can we deny it?—it is a spiritual life. For in Nature regarded as material there is none; nothing but dead and passive laws bearing incredible fruits; apparently effecting in their blind working results which express to us not only life, but love!

But these very laws themselves, sublime in their simplicity, carry their own claim to be held spiritual: they speak distinctly to our hearts of that which is not physical, but is kindred to the soul. For in thinking of this law of least resistance to which we have seen reason to believe organic forms are to be referred, how could I help perceiving such things as these? First, that, rightly speaking, it is hardly to be called a law at all: it is simply the na-

ture and necessity of things. Motion, as we have seen, can take no direction but that of least resistance: regarding the proposition in its most general form, it is less a "law" of motion than its nature. And, therefore, in the very constitution of the world, we perceive with an awful wonder that there are involved all the results of form and structure that are realised in living things. It is the exhibition to us of a fact to which, by its very nature, these results belong.

And if, again (calling our moral nature to aid and carry up our intellectual apprehension,) we look at this law to which we have traced the living structure, and endeavour to realise its significance, we feel that it is a spiritual fact with which we are in relation. Interpreted into moral terms, is not the law of least resistance this, *Action determined by want; giving, called into operation by a need?* Is not this "appearance," this disguise of a material law, worthy to present to us a fact of which the verity is love? It is love that appears to us under this seeming law of force; love not less demonstrated in its nature, than made manifest in its fruits.

Thus was first suggested to me a thought I have elsewhere pursued at greater length,[1] that this physical world, known to be an appearance (or phenomenon,) is the appearance of that spiritual world which we also know. It is not the phenomenon of a merely unknown existence therefore; but of that "spiritual" which has a moral nature, with which we associate the thoughts of love, of righteousness, of true necessity. The facts which life presents to us, when seen with the eyes of science, assert for themselves this character. We have to do with a spiritual fact in that necessity which makes living things what they are.

But this necessity is the same as that by which the rest of nature is what it is. The same law or necessity of force which determines the former, determines all. We learn better from the organic as it is nearer us; we see Nature more truly there where it is less beyond our scope. And thus I seemed to be taught that the essential fact which all things imperfectly exhibit to us is spiritual also, and fraught with moral elements.

The appeal lies here to the heart: and, surely, the

[1] See "Man and his Dwelling-Place," book I. chap. ii. *et seq.*

heart gives no equivocal reply. As plainly as facts can speak to the moral nature, does this fact of the union of perfect law and beneficent result, of a necessity so inherent in the nature of the case, and fruits which a moral necessity alone could involve, speak of a spiritual essence in that which we call Nature.

And then I could not but feel, too, what confirmation this thought receives from the light it introduces into our experience. When I bethought myself, again, what Nature is to us; what sensations connect us with it, what emotions gather round it; the conviction became overwhelming. It is the spiritual world that thus impresses us; that gives us an experience thus altogether above, and inexplicable by, the powers we can attribute to these phenomenal things. Viewed as the appearance of the spiritual, Nature becomes intelligible: Life, which science seemed to banish, returns to it; its mysterious capacity to move us receives its explanation; the powers of the soul find it a fitting sphere for their exercise, and prove their claim to be its best interpreters.

All which comes from the doctrine, established so

And I have thus briefly indicated the line of thought which led me to it, because I find it at once the fruit and the seed of the scientific knowledge of Nature. Even a slight understanding of the true order of physical phenomena, and of the significance of the physical laws, is sufficient to conduct us to it; from that point it becomes our guide. I shall therefore endeavour to place it in a little clearer light.

The assertion that our knowledge or perception is not of the essence of things, but of something merely phenomenal or relative, translated into more ordinary language, means that we are feeling things to exist which do not exist.[1]

Now, strange as this may seem when thus generally stated, there is nothing we can better understand, when it is expressed in matter-of-fact terms, and applied to particular cases. "We are feeling things to be which are not; our practically true is not the very truth." There is not the least difficulty in this: our practically true in any large matter is continually not the true. Is not the earth *practically*

[1] Thus, to illustrate the proposition, Kant takes a rose, and says of it—"The rose is not a thing in itself, but a mere phenomenon." But it is evidently the rose and nothing else that we feel as the thing. Of course, the same is true of our own bodies. Our own limbs also are but phenomena.

flat? Or again: it is the established doctrine of science, proved by overwhelming evidence, that motion, once begun, never comes to an end: the world is what it is because all the motion within it never ceases. Yet, practically, motion continually ceases: we have *consciously* to do with motions that, for the most part, come to a speedy end. Thus an unceasing motion gives us the feeling and the perception of ceasing motions; and the round earth gives us the feeling and perception of a flat one.

Our "practical," therefore, may not be the true in any case. In fact, it is evident that in any case in which we are relatively very small, and our powers are capable of apprehending very partially, it certainly will not be the true. It is not hard, therefore, to credit that our practical world altogether (this world of "things," as we perceive it, or of "matter and force," as science represents it) is not the truly existing one; but is only the inadequate impression we receive from a world of a different order. It is a question of our capacity to perceive.

But there are other illustrations which may serve to make this idea still more intelligible. We may

easily perceive how, not only a partial, but a universal feeling of the existence of that which does not exist might arise. Let us conceive, for example, the case of a person in whom the sense of *touch* was wanting—that is, who could see things naturally, but had not the power of feeling. It is clear that, by such a person, the appearances of things (which we and all who have their senses perfect feel and know to be but appearances) would be felt as having real and separate existence. He would have no faculty by which to test them and discover their true nature, not having any apprehension of that solid thing of which they were the appearances. Seeing a book or a chair, for example, in various positions, before his eyes, he would consciously perceive, not several appearances of one book or chair, but so many distinct things—realities, existences practically to him, because filling all his faculties, and exhausting the scope of his (maimed and mutilated) powers.

Let us observe well the point here: the deficiency of a faculty which belongs to our nature would elevate what are in truth mere appearances into a *felt* reality; would give them, to our feeling, a fic-

titious existence which they do not possess. On the other hand, the imparting to such a person (so feeling mere appearances to be realities) the use of his full powers—the giving back to him the sense of touch—would reduce these appearances again, in respect to his feeling, to their right position. From their false reality they would sink back into the mere appearances they are. And this by no loss, but simply by a gain to him.

Thus we see how the absence of a faculty is adapted to give us a feeling of reality in respect to that which does not exist:—in the case supposed, it would make that seem *real* which is but *appearance.* The same fact is presented to us in another form in the case (no more a mere hypothesis) of dreaming. In dreams, non-existent things are felt as if existing; we live, to our feeling, a life which is not lived, and amid conditions which are not. And this we do simply through the temporary abeyance or inaction of certain of our faculties. For this is the essential difference between dreaming and imagining. The very same thoughts which constitute a dream might pass through the waking mind in felt unreality, and constitute a poem or a tale. But some of our faculties are inoperative during sleep

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do not infer the existence of such sensations in Nature. They are our own merely; only the child fancies his pleasure or pain to be also in the things that impart it to him. But that which the child does in ascribing his feeling of pain to the insensitive table, we do in ascribing our feeling of force, which is really that of exertion, to the material world. Force can no more be separated from a perceiving consciousness, such as our own, than colour or sweetness. We are called on to recognise here, as we have already done in respect to other sensations, that our own nature contributes to them, and that our feeling is not the standard of what is without us, but the effect produced upon ourselves.

Now it is, doubtless, difficult to do this in respect to force, and to admit that it is not (as we feel it to be) in the very objects that seem to exert it. The difficulty is shown by the fact that the question still needs to be argued, and that the mass of men would be at issue with the thinkers respecting it. But from the point of view we have taken, at once the truth of the statement, and the source of the difficulty in receiving it, become obvious. If that which only appears is felt by us as existing, our feeling of force where it is not is an evident consequence. In truth,

this feeling of force in Nature is the very expression of the fact of our feeling as existing that which does not exist. It is rather that very feeling itself; for it presents to us objects as at once passive and yet acting—without power, and yet exerting power. It is, indeed, precisely in consequence of this feeling of force, and the merely mechanical character which belongs to it that men have ascribed deadness to Nature, and spoken of it as "dead matter." The acceptance of force as arising only within our own feeling is the conceding a spiritual existence to that which is without. Thus the persuasion that force is in Nature cannot really be given up, but with the admission of an untruthfulness in our feeling of existence. The two things are inseparably joined. Physical objects exert force as truly as they exist; and they do both alike only to our feeling.

So in accepting that thought of man's condition which involves such a falsity of feeling on our part as its result, this difficulty respecting force, which else meets us on the threshold of our inquiries, is cleared away. The feeling of force where it is not is implied beforehand in what we have already learnt of ourselves and of Nature.

And so we may advance unimpeded to other re-

sults, which are of the greatest scientific import. If the physical world is the changing appearance of some unchanging existence, there must be in it a perfect order through all its changes, and an essential identity at all times. The force apparent in it, therefore, will be at all times equivalent. It will change its forms, but never vary in itself; it may become hidden, but it cannot cease. That necessity of order which belongs to an appearance necessitates this. There cannot be true variation, because an appearance cannot change itself.

Thus, not only is the apparent merging of each form of force—motion, heat, light, affinity, &c.—in each other, with no loss or gain, a necessary part of the order of phenomena,[1] but another character of force, which is involved in this, is also seen to be necessary, and to be full of a significance of its own.

For, if the amount of force is always the same, and every process in which it is concerned is a change merely of its own form or place, then every such process must have two aspects: on the one side

[1] For the discussion of this subject the reader is referred to Mr. Grove's admirable treatise on the Correlation of the Physical Forces; it has been briefly treated by the writer in "Thoughts on Health and some of its Conditions."

force comes into play; on the other, to an exactly equal amount, it ceases. Its operation is always and inevitably an equal plus and minus. There cannot be the one without the other. Every physical process is, necessarily, the adding of force in one direction, the withdrawing it in the opposite, and may be represented by the equivalent, but opposed, motions of the two sides of a balance. This we have seen to be the case in respect to the organic world. Organic life, taken as a whole, presents itself to the eye of science as a vibration. It is summed up in opposite and equal processes. And this idea applies equally to the whole sphere of physical events. However varied, however vast, however minute, may be the changes which mark the course of Nature, they all have this character. Nature vibrates, with perpetual plus and minus; it vibrates, and no more. What music it thus makes in the ear of Omnipotence, into what vast symphony its endless, unintermitting, infinitely-varied pulsings may be wrought, we know not. It is enough that the Great Musician knows. But this we cannot fail to note: that be it wrought into whatsoever forms, spread out over whatsoever time, equal plus and minus are—nonentity. An *o* analysed and spread out, and made to

seem to be:—this is what the physical world avows itself to the long-gazing, and at last penetrating eye of man. So much to him, so much in seeming, is it truly nothing then—a painted vision, and no more? Must we mourn the loss, the utter sinking away of our imaginary world into a false play of illusions?

It is not so. Already we have known, and have rejoiced to know, that Nature, as we perceive it, is but a vision; for it is a vision presented to our eye by that which is infinitely more. This inverted telescope of science which dissipates the galaxies and dissolves the stars, reducing Nature into nothingness, strikes us with no astonishment, fills us with no dismay. This solid-seeming universe may fade before its gaze; it does but bring into a surer presence of the things that are unseen.

CHAPTER XI

THE ORGANIC AND THE INORGANIC.

If the ideas we have been considering in respect to organic life are true, we cannot but feel that, to a certain extent, our former thoughts have been inverted. We have long been accustomed to hear it assumed, that the organic world is distinguished at once by a special eminence over the rest of Nature, and by a special mystery; so that it is that which of all things we can least hope to understand. It seems to me, however, that this idea is the very opposite of truth. So far from being less comprehensible than the rest of Nature, the organic world appears rather to be that very part of it which we may most truly be said to know: the inorganic world with its deep-hidden forces is the mystery. For it must not be forgotten that, in discussing organic life, we pre-suppose the chemical affinities; and these being taken as our postulates, the phenomena of the organic world are of the kind which we best understand. As based on an opposition to the chemical affinities, and as displaying powers due to the

force thus stored up, life presents to us no mystery. Almost we might say that it exhibits to us, under this aspect, the one thing in respect to the natural forces that we may be said to comprehend: the production of a *tension* and its results. And remembering the effect exerted by the forces of Nature in maintaining and increasing the tension, and by mechanical conditions in moulding the material so produced; remembering these things, we can hardly call life mysterious at all. It presents to us a lively instance of known, and, in one sense, well-understood phenomena. But there is a mystery in it, doubtless. In making us conscious of the presence of a mystery it has done us good service, though our wonder has been misplaced. The organic life we understand; but those wider forces and affinities which underlie it, and by virtue of which alone it can exist, contain a yet unpenetrated secret. It is to these we should turn our admiration and devote our curiosity. All the activity we see in the organic world is derived from them; from them are borrowed all the complex structure and mutual adaptations it displays. We have magnified the little and despised the great.

And naturally we have done so; for, in truth, this

feeling of ours respecting the organic and inorganic worlds is a legitimate fruit of our ignorance. Where we have known least we have seen least, and have felt least wonder. Our ignorance where most profound has been least visible to ourselves. This poor organic life, being, as it were, our own, being the part of Nature nearest to us, least above us—being, perhaps we might say, the part of Nature which is brought down within the sphere of our appreciation—this we have seen truly enough to perceive its wonder; knowing it better we have regarded it with a peculiar awe, and have arrogated to it a peculiar value. The inorganic world being larger, on a grander scale, and devoted to ends less fathomable by our ingenuity, this we have not known well enough even to discover that we do not know it. It has seemed less to us because farther from our eye; more simple because our vision could not trace it. We have seen life no farther than the life that is like our own extends.

In another form we may perceive a similar result of our limited apprehension of Nature; namely, in our belief that consciousness is confined to the animal creation and mysteriously associated with one portion alone of their physical structure. Perceiv-

ing all Nature as unconscious, save ourselves and creatures organized like ourselves, we assume that Nature is an unconscious thing, and that here and there a little consciousness is imported into it from without. But what are the facts? At one small corner of Nature we perceive it (we may say) directly, we are in immediate contact with it—namely, in our brain: and there we feel it as conscious. At every other point we perceive it only indirectly, through channels which hide as well as reveal; and there it appears unconscious; or conscious only by inference, from resemblance to ourselves. Where man and Nature touch, he feels Nature to be not only the possessor of consciousness, but the reservoir, the holder, of his own. Where he is parted from it, and obtains his apprehension of it through senses which present it partially and at second hand, the consciousness is wanting; he apprehends brute matter only.

Is not the true interpretation of these facts obvious when we reflect on them, once freeing ourselves from the natural assumption into which our limited feeling has betrayed us? Is it not this: that Nature is a conscious existence, and that the apparent absence of consciousness from it arises from our

non-perception? Just as a conversation, rich with love and wisdom, heard at a distance, becomes to us mere sound.

And thus we return to our former thought, that in the unconscious things we find around us we are dealing with an appearance, not with Nature as it is. That is a conscious existence, which to know fully were to have that wider life and deeper consciousness for which our hearts cry out. "To be one with Nature" were not to lose our sense with life, but to have it freed from the limitations which hedge it about and make it teach us falsely; it were to share, in living truth, the joyfulness, the passion, the repose, the rightness, which even now Nature images, though faintly and but afar off, to our hearts.

There is yet another respect in which it seems to me our thought of Nature is inverted—naturally inverted owing to our partial apprehension, but in a way that corrects itself with growing knowledge. We think the organic world—that in which we discern the marks of life—the highest part of Nature; it truly is the lowest. We have seen that, viewed by the eye of science, it is shown to be distinguished not by the addition of anything, but rather by an

absence. It springs from the all-pervading order of Nature by a limitation and confining of her powers.[1] Seen by the eye of the soul, it exhibits the same character. Organic life shows us the good powers of Nature perverted to purposes that are not good. And thus our mingled feelings in respect to it receive an explanation. We admire, and cannot but admire, the order, the mutual subservience of all the parts and their interworking to common ends, which the organic world displays. And thus, thinking that these characters of beauty and of order pertain exclusively to that region (where alone it is visible to us,) we have naturally concentrated our admiration upon it, and have been almost forced to think admirable, also, the ends which are thus subserved. We have been compelled to accept organic life as excellent in its results and apparent objects, as well as in its means; thinking the wonder and beauty of those means were introduced for those results alone! But how much more beautiful a thought is open to us when we look on the organic part of Nature as, in these respects, but an exhibition of the whole: and what relief it brings to the moral constraint with which we have forced our-

[1] See chapter vii. p. 177.

selves to regard the universal rapine and utter self-hood of the animal creation! Instead of possessing a superadded and especial excellence of order and adaptation, the organic world does but bring the universal order and excellence of Nature into our little sphere of vision; there it is displayed on a scale small enough for us to see, and we see it beautiful. Forgetting this, we have extended to the negative and evil elements, which are peculiar to the organic world (the subordination of everything to self-preservation and individual ends,) the feelings which are appropriate only to that in which it is universal; we have carried on to the ends, the joyful admiration with which the means affect us—doing violence to our souls therein. Nature is beautiful, and in its organic applications we see its beauty; self-ends are evil, utterly and for ever, and in the organic world we see Nature's beauty perverted to that evil.

Thus, there rightly arise in us the mingled feelings of delight and disgust, of admiration and of loathing, with which we look on the animal creation. Each of these feelings has its perfect justification, and its perfect place: the joy and admiration should embrace all Nature; the loathing

concentrate itself unchecked upon the purposes to which in the animal world Nature is debased. It is not life, this mere self-centred isolation; it is the mockery of it: an inverse, perverted life, laying its cruel bondage on our own souls too. But we hope for deliverance.

Animal existence shows us beautiful means perverted to evil ends: the glory of Nature's order yoked to the base car of self. But it is not perverted thus, unmarred: even in mechanical adaptation the organic is the weak part of Nature; not as it seems to us, the strong one. The glorious sweep of her order refuses to revolve around that miserable centre of the self; frailties, deformities, diseases, bear witness to the strife, and testify the nobler sphere to which her powers are vowed.

CHAPTER XII

THE LIFE OF MAN.

BUT though organic life exhibits Nature thus bounded and tied down, its characters are not the less rich in meaning. The laws which rule in it are the universal laws, and speak the universal language, exhibiting spiritual things to the eye of sense. What other than a spiritual fact is this, the most essential character of life: that it depends upon the resistance or control of one form of force by another? A passive force (properly called a "passion,") kept in subjection, and only in regulated and determined modes suffered to come into play;—on this the seeming Life in Nature depends. Does it not speak to us of that control of passion which is Life indeed, within us? Only by resistance, by restraint, is Life. The passion on which it rests, uncontrolled, leads to corruption, ends in death.

We cannot but be struck with this fact in the history of the seed: opening the eyes of our souls to read it. Operated upon by the forces which bring its latent "passion" into play—the chemical affin-

ities which its elements contain—the seed begins to undergo a change, the decomposition of its subtance. But mark the difference. This change arises alike in the fertile and the infertile seed; it is the starting point at once of death and life. Resisted by the germ, it becomes the source of living action; it is the very power of growth; the chemical change, controlled, constitutes the life, and forms the basis of all the subsequent development: if unresisted, the seed decays; it sinks into corruption and is lost. Passion resisted is the source of life. Can we fail to hear in this a voice which addresses itself to our manhood? or to recognise a spiritual fact—a fact which our hearts alone can know—veiling itself behind these seeming laws of force?

Throughout all life it is so. The one fact of the control of passion is presented to us in all its forms. The law of *tension*, translated out of the passive phenomenal terms into language that our souls can recognise is this:—it signifies holiness, rightness, self-control: it is our own Life portrayed before our eyes. The spiritual is made to "appear" to us, it is brought before our very senses, in these phenomenal laws of force, in which it is not, and yet is.

Again, how well we see herein how man differs

from Nature: what his fatal prerogative is. In Nature passion is controlled; in man the control is wanting. Where Nature rules and lives, man is a slave and dies. His passions (which duly subjugated are the very source and secret of his life,) running riot without check, work in him mere corruption, and consume his manhood. Placed side by side, we see again, Life in Nature, Death in Man; a "law of death, working in his members."

And let us note again, how the evil of our present state is not our being in an evil place. This world which we call Nature is not evil, it is the very appearance of the spiritual, of the highest and most perfect Life. It is most right to appear; but our evil case is that we are feeling it to be not an appearance, but the very truth. It is this makes the good evil to us, and the very image of love to be a bondage and a snare; makes us cry out on death, where only life is to be found. We see how evil it would be for us to feel the visual appearances of things as if they were the reality, and to be acting so. They would lead us into error, failure, sore perplexity; we should cry out to be delivered from them, from a source of evil so pressing and so constant! And yet how right and good it is that these visual ap-

pearances should be. How well it is for us to perceive them, knowing and feeling them to be what they are; to see them, and yet not act, nor find it possible to act, according to them.

It is thus with Nature too. Perfect our being, and make us know it as it is, and it is no more evil, nor the source of evil to us: it could no more tempt or deceive; felt as appearing only, the appearance loses its perverting power; no more should we do, or find it possible to do, the things which now it is so hard for the best of us to avoid.

And again, seeing the relations which force bears in the organic world, we have a key by which to interpret it, wherever it extends, and in all its applications. The resistance to force—the action failing of its end—in the living tissues, is *nutrition;* the liberation of that force effects a *function;* the former exists for, and is the condition of, the latter. Nutrition and function—organisation and end—these are ideas which life associates with the operations of force, and they belong to it simply as force. It has no special endowment or prerogatives in the organic world; it presents simply its universal characters; and presents them there to our eye most truly. These ideas of nutrition and function are not

of special, but of universal scope. All storing up of force is a nutrition; all liberation of it is the effecting of a function. To see the world as it is, we must carry this picture in our eye: to feel it rightly, our hearts must cast all things into this mould. For it is not in the material alone that this law has its place. It extends as widely, and soars as high as Life; it is the key above all to our own. All strife and failure, all subjection, baffling, wrong;—these are nutrition, they are the instruments of Life, the prophecies of its perfect ends. They store up the power, they make the organisation; and where these are, the function shall not fail. Life is in that which we call failure, which we feel as loss, which throws us back upon ourselves in anguish, which crushes us with despair: it is in aspirations baffled, hopes destroyed, efforts that win no goal. It is in the cross taken up. The silent flowers, the lilies of the field, teach us this lesson too. Nature takes up her cross; loses her life to gain it.

Thus Nature, which is so full of undefined, yet mighty spiritual significance, while it is yet not understood; which impresses our senses, and our hearts through them with dim foreshadowings and glimmerings of the holiest things;— Nature, which

is thus vaguely spiritual to our sensuous feeling, and which for that reason appeals to us so strongly through it, and is so dear to us;—which the poet sees flowing with springs of living water through every pore, yet half suspects them to be but the mirage of his own longing eye—seen according to the strict laws of science, is richer still with spiritual meaning. The indistinct and half-doubting emotion of delight and awe expands itself into the clear apprehension of a spiritual order, and rises into an infinite and confiding joy. Rooted in a new and richer soil, the tree of our delight spreads out its branches in a sunnier air. It is no longer our mere impression, still less our mere fancy, to which Nature speaks of holiness, of peace, of joy, of sacrifice, of that which we most long to find in it; it speaks of these things to our whole being. Every faculty finds rest and satisfaction in it. It is no more one thing to our heart and another to our thought; it is wholly one; the best and highest appearing to us, as to us in our lowliness it can appear; claiming to be known and understood, as by the best and highest in us, alone, it can be understood.

The reducing all events in Nature to the mere play of forces, brings, in the end, this lesson; our

souls, which it threatened to starve, it fills with a higher life.

But we naturally ask further—if the physical be the appearance of the spiritual world, how can we connect the one with the other in our thoughts? How shall we look through the apparent to the actual, and give to each object or event among these things which we feel as real, its true relations? What, for instance, is the spiritual object presented to us by a tree, what by a rock, or house, or article of ordinary use?

In order to deal rightly with this question, neither lightly dismissing it as absurd, nor attempting vainly to give it a premature reply, we must recognise some other facts respecting Nature and our own relation to it. Especially we must remember, that in order to discern this relation, we must look, so to speak, along the line of physical events, and not across it. Each material object, as it arises in succession, is a new form or presentation to us of the same essential existence that was before; itself will pass away, and another form of that same existence will take its place. That existence, therefore, is not to be identified with individual things (which are but differing forms of the same,)

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but is that which the whole succession represents. Thus, to take an instance, our question is not, What spiritual existence is perceived by us under the form of a tree? but, What presents itself under all the series of objects of which that tree is one? What is it that appears to us under the form of seed, of soil, of air, then of the organisation of a tree, then, it may be, of ashes, flame, and smoke, and so on; both before and after, in an indefinite succession? It is one existence that is presentd to us throughout all, just as one solid may be presented to the eye under many different points of view. In seeking to learn the actual from the phenomenal, we must remember this, and frame our thoughts accordingly. What one existence makes us perceive in ways so manifold?

How far it is possible at present to advance, or whether it be possible to advance at all in this inquiry, we need not here decide. But one interesting question presents itself upon the threshold of it, a consideration of which may tend to make our path more clear.

Nothing in Nature changes but the appearance; it is the varied representation to us of an existence which is ever the same. These changes of appear-

ance, therefore—that is, the entire succession of change known as the "course of Nature"—might be perceived by us through either of two causes: either a change apart from us, presenting the same existence differently: or a change affecting ourselves, and placing us in different relations to that existence.

It is our nature that by changes of our own condition we are made to feel as if other changes were occurring before us. In those dioramas, for example, in which the picture is fixed and the spectators are carried round, the impression upon them is precisely the same as if the scene moved before their eyes: nor is it possible for them to obtain any other. In a similar way, we are conscious of perceiving a succession of light and darkness—of day and night—while there is truly no such succession. There is a space illuminated by the sun's rays, and a shadow cast by the earth: our succession of day and night is but our being carried alternately from one into the other. In this case all men receive the same impression of external sequence from a change which affects them all.

It is clear, therefore, that a change affecting all men in common would perfectly account for the

fact of their perceiving the changes that are perceived in nature. It would account also for their natural persuasion of the existence of these changes as external.

And there are reasons which command us to take this view. The fact that the "course of Nature" consists in changes of form or appearance only, and involves nothing deeper there, is itself no inconsiderable evidence. For this is a result which a change affecting man would necessarily produce upon his consciousness. It is so, indeed, that we are ever made conscious of changes in ourselves. Therefore, it might be urged, since man is himself the subject of change, and the changes of appearance which we term the course of Nature are of the kind which change in him would account for his perceiving, and since no other such effect of the change to which he is subject is apparent, his perception of the course of Nature should be referred to this cause. It is the simplest view; it involves the least assumption; and claims on that ground to be received.

But there is other evidence. Some is derived from the Nature of *force*. If this be only felt by us, and do not exist in Nature, it is a strong proof that the

change with which we connect it is also in ourselves. To deny force in Nature, and leave there the change with which we feel it to be connected, seems not possible. To claim force as seated in our own feeling, implies that the change is also in ourselves; that we are altered, and not Nature, in her shifting phenomena.

So the feeling of force would be associated with change in man. We feel ourselves, when exerting it, changing that which is without us; but it is truly humanity that we affect. We can picture the idea to ourselves by the aid of a familiar illustration. A rower on a stream exerts his strength upon his oar, and perceives the shore as if it moved!—and not he only, but all who may be with him in the boat. The exertion of his force, affecting their common condition, presents to their perception a common change in the things around.

In the view we thus take, many advantages are found. Our thought of Nature is at once simplified and elevated. Instead of feeling ourselves to be a fixed centre, before which a mechanical universe marches with dead footsteps, we rise to the conception of a larger and sublimer universe, of worthier ends and grander sweep, upon the tide of which

our little lives——nay, man's own larger life is borne; the true order and course of which includes the changing consciousness of man, painting so upon eternity for him a visionary Time; which has for one of its least elements the pulsing of his heart and throbbing of his brain, which is enriched with all his passion, and bears his life-blood as a drop in its warm bosom; all being faintly imaged to his unperceiving eyes in changing garniture of earth and sky, from year to year.

Thus we do not seek any longer to attach our marvellous consciousness to these passive things which seem, but cannot be, its causes. It has a worthier, a more reasonable source. These material things (which are found to be mere "phenomena") and their changes (in which there is no change) are not the causes of that which we experience; they are the appearances which a deeper cause, unseen, brings up before us. They are projected from our eye, and have another lesson for us than that which we read upon their surface. Surpassing them as they surpass a dream, stands the true universe which they reveal.

And not only is our thought of Nature raised and made clearer by accepting a change in man as

the cause of our perception of external change; a new proof is given to us of the unity of men. For not only is the change which affects us common to all, and the same in respect to all, but the action of any one of us is shown to influence the race; because all men perceive, or may perceive, the effects of the actions of all others. Since the action of any one man changes, really or possibly, the consciousness of all—as when one man moves anything, all around perceive it moved—it follows (upon the supposition that has been made) that all are united with all others, though they may be unconscious of the tie, and partake in that which each one does and is. It must be so, if the effects of our actions are truly wrought within and not without. Humanity is proved one by all the evidence which goes to establish that the seeming changes perceived around are signs of a true change that takes place in ourselves.

And these two thoughts conduct us to a result in which, while we press forward towards farther light, we may yet rest with present satisfaction. If man is one, and if some spiritual work, pertaining to humanity, and embracing, therefore, every

member of it, be the true cause of all that we experience, then our hearts, at least, may be at rest. The universal Life bears man's destiny within it: and not the meanest labour, the most trivial accident, fails of contributing its part. If, as we have seen, to understand our life, we must look beyond the seeming, we see here the guide by which we may interpret it. The carrying out of a change in man, this is the meaning of it; this the unseen fact. It is not wasted as it seems.

And yet once more our hearts turn to Nature as their guide. What is it that is imaged there? What fact presents to our eyes this scene of mingled life and death, of ruin and of order, and reveals to our more humble and instructed gaze life springing out of death, ruling decay, embracing ruin as its instrument? What is it shows us *becoming* as its constant law; the loss of each thing for the being of each other; all giving itself for all; life dying that other life may be; dying, but in that very death most truly living?

What fact is imaged here? What is the keynote of this mingled harmony? Do we not hear it in one word—Redemption? Of death, and life raised up

from death; of life bestowed by death, and perfected through it; of sacrifice, which is the law of being and the root of joy; of these things Nature speaks to us.

CHAPTER XIII

CONCLUSION.

It may probably be felt by those to whom the ideas on which I have thus briefly dwelt are presented for the first time, that what I have said amounts merely to suggestion, and that of a doubtful character. I may say, therefore, that I have designed my remarks merely as suggestions; and have sought only to present an outline of certain methods of regarding the great problems of our life, which seem to me to possess a good foundation, and to promise results of a different character from those which the methods hitherto in use have yielded, at least in recent times. To suggest, ever so imperfectly, ideas of this order, if they should be found to have a real value, seems to me a task worthy of the highest efforts. Nor do I believe that they will be entirely in vain; because the ideas themselves seem to me to be not the hasty speculations of any individual, but the legitimate fruit of time. In so far as they are true, they are a boon which our dead fathers have won for us—the inheritance with which they have enriched us.

Can we believe that the long inquiries of men into the facts and laws that are presented to their senses should fail to give them an increased power of dealing with other facts and laws, of which not the senses but the heart and soul take cognizance? Or can we believe that any other result should ensue from his increased power than that the demands of man's moral nature should be proved true, also, to his intellect?

I am myself convinced that the chief obstacle, now, to our advance in this path is the conviction that it is closed to us:—a conviction natural enough, indeed, through repeated failures, yet by those very failures proved untrue. If in this volume I have done anything to shake this conviction in any mind, and to induce the feeling that it may be premature and presumptuous, I have done enough. That little, or even nothing, is completed in it, I shall hold a light reproof. How should that present finished results which waits even now for its beginning? A field ripe for the harvest does not yield loaves of bread.

We are in some degree sensible of the presumption which may be involved in bold speculations and large expectations of knowledge; but we think little of the presumption that is involved in denials

and in the assumption that we can mark out limits. Our pride may pass if it will but wrap itself in the cloak of humility. Yet I venture to say, that no presumption of extravagant affirmation that has shamed the past, equals in presumptuous arrogance those bold negations and prophetic mappings out of man's capacities, for which our own age will have to blush. Nor does it affect this question, that the men who have propounded these invertedly ambitious doctrines have acted under the influence of the best motives, and have been men of an eminent modesty. Private conceit is seldom an accompaniment of eminent ability; nor is there any reason to believe that the most audacious speculators of former times have been wanting in personal modesty, while their aims have been unquestionably good. Happily, the human destiny is ruled by higher powers than the personal characters of men; nor could it be otherwise than that, in its aspiring vanity, the mind of man should swing from the positive to the negative side—from absurd assurance of knowledge to absurder assurance of inability to know—before it finally assumed its true level, in a hopeful, laborious, and confiding patience.

When that time comes, I think it will be seen

that the real difficulty we have encountered—the real source of the despair which has seized so many of our chief thinkers, and has made them (against all their best native instincts and acquired tendencies) presume to limit the possible advance of man, even though they thus debarred him precisely from those gifts which are of highest value—has been our not expecting enough. We have failed because we had cast our reckoning of God's bounty too low—as, indeed, how could we do otherwise? We have despaired because we could not believe in, nor receive, a gift so rich as He has given us.

A little petty perfecting of knowledge, such as we have aspired after, we shall never have; they tell us most truly who tell us so. God forbid we should—forbid that His givings should be limited by our desires; His bountiful surprises by our anticipations. But, darkened by our own expectations, and seeing nothing but their failure, we do not see that they fail only because a success altogether beyond any possible expectations is placed in our hands; nay, that in this very failure that greater and better success consists.

We may see this greater success involved in our seeming failure in two ways:—

First. If we find that all our attempts to fathom existence by thought are in vain, and that we can only arrive at conceptions which cannot be the truth because they involve contradictions; then how can we fail to see the different attitude in which our emotions and our moral feelings are placed in regard to our belief? If that which we can conceive cannot be true, then why may not our moral powers be, in respect to truth, the guide and judge? The idea, which naturally arises when the short-coming of the intellect is realised, that we have no power of knowing, is based only on forgetfulness of the fact that we have powers which mere intellect does not include, and to which the intellect may be made the servant. If our thoughts have not authority, our hearts may be made judges. This is given to us in the seeming denial of our power to know. We may translate all that the intellect can apprehend into moral terms; may read in it a spiritual significance; may affirm *that*—duly fulfilling the conditions of the case—to be the truth. From that which the heart knows we have to trace, as an appearance, that which the intellect and the sense perceive. Some little attempt towards this I have made in the foregoing pages.

Or, secondly, we may think thus: suppose, instead of seeking to penetrate the Nature of things, men had been trying to discover whether *man* was in a normal or a defective state; had been seeking to discover this as a necessary preliminary to the solution of ulterior problems. Then would not the discovery which now seems like a fatal bar to knowledge—the discovery, namely, that our perception and feeling are not true; that we naturally and universally apply the idea of existence falsely, and only by long effort learn that what we take for existence is but phenomenal—would not this discovery have been hailed as the very answer that was sought, and as a step of most hopeful augury? This means that man is in a wanting state.[1] It is the starting-point of inquiry, not the end. It seems like the end only because we have not been asking the right question. We have been seeking wrongly, but God has answered us aright.

For it is wonderful to see what a new light arises, and what doors open, when we take as a guide to our thoughts this idea of a false feeling, arising from a wanting state, in man. It is, in one aspect, one of the least results, though in another it is the sum of

[1] See Chapter X., p. 220.

all, that our whole thought, our very science, is made Christian.

Inconceivable things are given us through this knowledge respecting man, which comes to us in the deceptive guise of an inability on his part to know. It were not possible to have believed that so much was in store for us. I know no question that the intellect desires to pierce, or the heart in its secret chambers weeps over or tries to forget, which does not stand in a fresh light before it, and bend itself to give it confirmation. Unwittingly to ourselves, God has kept us in the right path, He has made us do what we had no thought of doing.

Do not *we* deal so with our children?

[illegible]

My Highness certifies that this is a very good book.

[illegible]

Aug. 20. 46

1. 9. 43.

APPENDIX.

AN ATTEMPT TOWARDS A MORE EXTENDED INDUCTION OF THE LAWS OF LIFE.

[*The following is the Essay referred to in the Introduction and at page 99.*]

THE motion of a pendulum consists of two portions —a downward movement caused by gravitation, and an upward movement, theoretically equal in amount, which is produced by the momentum arising from the former. The essential condition of the sequence of the upward movement is that the downward movement should be resisted in a definite manner. The gravitating motion, not being completed, becomes a motion opposed to gravity.

The molecular changes recognised in living bodies are of two kinds—those which result in that arrangement of the particles which constitutes organic matter, and those which tend to reduce organic matter to the condition of inorganic compounds. The former of these motions (or forms of

action) is known as nutrition, the latter as decomposition.

It is sometimes said that decomposition results from the operation of chemical affinity, and that nutrition is the operation of the vital force. I shall for the present use these words with these meanings. If the idea of a resistance to the motion of decomposition be introduced, it may readily be conceived that the chemical and vital actions (as above defined) bear to each other the same relation as that which exists between the downward and upward motions of a pendulum. The chemical motion, not being completed, may become a motion opposed to chemical attraction.

The proofs I shall adduce of this hypothesis are—

I. That it is indicated by the phenomena of life.

II. That it is conformable to the general course of Nature.

I. It is indicated by the phenomena of life.

I do not now speak of the origination of life. As, in treating of the motions of a pendulum, the existence of the pendulum and its first upward movement are assumed, so I assume for my present purpose the existence of organised bodies, and

therein of that organic arrangement of particles which I affirm to be thereafter renewed and increased through the medium of chemical action.

Nor do I now speak of the forms assumed by living substances, or that which is properly termed Organisation. The following remarks relate to the primary fact of life, the production of organic matter.

And further, I do not design to attempt a complete explanation of the facts to be adduced. I consider them in that relation only, in which they may serve to indicate the chain that connects vital action with the material changes which directly and casually precede it.

In the vegetable world, the dependence of vital action upon an incomplete or resisted process of chemical change is indicated by such facts as these.

The fertilised seed grows as it decays.

The chemical process of fermentation maintains the growth of vegetable organisms.

Organic matter, of whatever kind, spontaneously decaying in the presence of the atmosphere, seldom fails to be covered with fungi and other plants of a low type.

The ordinary growth of plants has been shown

by Müller to be intimately connected with chemical or decomposing changes occurring in the soil.

The decomposition of carbonic acid and production of organic matter by the leaves of plants has been shown, by Dr. Draper, to involve a decomposition effected in the leaf by light.

In each of these instances the vital action appears to be the secondary process. The infertile seed decays in the same manner as the fruitful one. Fermentation may take place without any development of the yeast plant, although less rapidly. Ordinary putrefaction and decomposition of the soil are not necessarily dependent upon the development of living structures.

In the phenomena of animal life a similar relation of vital to chemical action may be traced.

The egg in the act of development absorbs oxygen, and undergoes also, in part, a decomposing change.

Vegetable infusions, while decaying, swarm with animalculæ; and putrefying animal bodies are thronged with forms of life.

In the act of digestion, the first stage is one of decomposition of the food.

Blood is arterialised by the union of oxygen with a part of its constituents.

In one form of the multiplication of cells, a parent cell decays while others are developed within it.

In the successive formation of hairs, the new hair, as described by Mr. Paget, appears to be developed as an offshoot from its decaying predecessor.

Functional activity, which ever involves a disintegrating change, is a cause of increased energy of the nutritive process.

The decomposing changes which constitute secretion, as in the liver, for example, appear to institute an increased development of the vital condition of the blood.

I have enumerated these simple and well-known facts with a view of indicating the broad basis upon which the general idea of the direct dependence of vital on chemical processes reposes.

If they be more closely regarded, the conception which they convey to the mind, either singly or together, becomes more distinct. The chemical affinities of the elements of organised bodies are common to them with all other forms of matter,

and constitute, therefore, a legitimate starting-point. These affinities, the conditions being suitable, give rise to a molecular motion which has been aptly termed downward, and which, if it continue, ends in the production of the simplest compounds. But if this movement be resisted or interrupted in its course, there will exist, as it were, a momentum of motion, which must take another direction, or exist in another form. Now, a molecular motion of chemical character, but in a direction different from that of the chemical attraction, constitutes the very definition of vital action or of life. It is an upward molecular motion in relation to decomposition as a downward one. The decomposition and the life, taken together, resemble, as before suggested, the movement of a pendulum. They make up a true vibration.

Whatsoever may be the exact nature of that attraction which is termed chemical affinity, there can be little doubt that it includes as one element a tendency to the approximation of certain particles. It is in one aspect, probably in its primary aspect, an approximating force. In this respect it presents an analogy to the force of gravitation,

which it can hardly lead us into error fully to recognise, and on which, indeed, the illustration of the pendulum is based.

If we now endeavour to carry the conception of the vital process more into detail, the view which has been taken of it affords an easy clue.

In the act of chemical change certain particles of matter are approaching each other, moved thereto by mutual attracting influences. If it be conceived that from some cause (not as yet defined) the perfect approximation of such particles is prevented, what so naturally ensues as that they pass by and go beyond each other, the very impulse of their attraction becoming thus the source of their separation?

What else have we in life? Is not the living body constituted by certain particles of matter endowed with approximating tendencies, yet carried perpetually into divergent relations?

Again: Particles of matter carried by an approximating force thus into a state of divergence tend perpetually to renew the approximating motion. The divergent state is in itself entirely unstable. The upward motion of a pendulum is the

type of it—a state of ever-changing action, which no sooner attains its maximum than it begins straightway to decline. Is it not so with life?

Upon the view thus presented, it is easy to conceive of life as a state of action contrary to chemical affinity, but constantly maintained by the operation of chemical attractions. It is not less easy to understand how the vital action thus arising should be increased or intensified beyond such an amount, or such an energy, as would be proportionate to the original chemical affinities from which it springs. The downward motion of a pendulum becomes an equal upward movement, the loss of motion from friction and the resistance of the air being allowed for; but if this downward motion be accelerated or increased by any other force acting, or capable of acting, in the same direction, the upward movement is proportionately greater. Thus the vital action which ensues from any given chemical change may have added to it, as it were, the momentum of whatever forces can add their impetus to the molecular movement which constitutes the chemical change.

How much of heat, or light, or electricity comes thus to assume the form of vital action, may per-

haps be estimated by the amount of the absorption of those forces which may be found to accompany the vital processes.

But to embrace all the phenomena contained in even the simplest idea of life (regarding it, that is, as the mere bringing into existence of organic matter) it is necessary to extend somewhat the conception I have suggested. In the vibration of a pendulum the same portion of matter falls, and rises again by virtue of its fall. But a falling body may impart its momentum, and, not rising itself, may cause in other matter a proportionate upward movement. The requisite mechanism is simple, and involves only the one condition, that the body receiving the impulse shall move most easily in the desired direction; that is, its motion in other directions must be resisted, or resisted *more*. The postulate is, as before, *a definite resistance*.

The same thing is presented to us, in a still simpler form, in the transference of heat from one body to another; the one becoming warm as the other cools, and in consequence of such cooling, or in the action of an ordinary balance, of which the one arm, by its fall, causes the rise of the other.

These few conceptions, gathered from familiar

facts, give us, to a certain extent, a perfect grasp of some of the most baffling phenomena of life.

As one example, let us take the germination of the seed. Put into conditions which elicit, or permit, the operation of the chemical affinities it begins to decompose. The downward, or approximative, motion thus arising, imparted to other elements in the seed which are so constructed as to admit of motion most readily in the opposite or vital direction, becomes in those elements a motion of life, or growth.

One fact connected with the germination of the seed deserves especial notice, namely, that it is attended with an increase of temperature. The growth cannot, therefore, result from a conversion of heat into any other form of force. The true idea would seem to be, that there is, as it were, an excess of chemical action above that which becomes the vital action; and which excess, therefore, assumes the ordinary form of heat. A falling body, if it imparts its entire momentum of motion to another, produces no heat: but if only some of the motion be imparted, a proportionate amount of heat is manifested.

As another instance, we may take together the

growth of mould on decaying matter, and the process of digestive assimilation. The forces at work, and the mode of their operation, appear, in both these cases, to be the same as those which we have traced in germination. The chemical motion of certain particles becomes the vital motion of certain other particles, which present to it an appropriate resistance. The vegetable germs which develop into the mouldy growth, represent accurately enough the living cells, or other organisms, with which the decomposing food is brought in contact.

The oxidation of the blood present the same idea to us perhaps in its simplest form. Certain particles of the venous blood enter into union with the oxygen of the atmosphere, with formation of carbonic acid: a manifest process of decomposition. But another part of the same blood, which resists this decomposing action, or refuses to undergo it, receives therefrom an impulse which causes its higher vitalisation and fits it to be the agent in nutrition. Is there in this process, regarded in its general outline, and apart from theory, anything more hard of comprehension than the coincident fall and rise of the respective arms of a balance?

In the same light, also, may be viewed the higher

vitalisation of the blood effected by its partial decomposition in the secreting glands. And with these may be classed the excretive or other decomposing changes which so generally accompany the process of metamorphosis. The silk worm spins its cocoon by a decomposition or retrograde chemical action, which imparts to the remaining blood a higher vital status fitted for the more elevated grade on which it is about to enter.

The process of digestion, however, presents other points which claim remark.

In the first place, those substances only which are undergoing, or tending to chemical change, will serve as food. The food supplies not only the materials for nutrition and for the production of heat, but, in the form of its decomposing action, the *life* of the being which consumes it. Without the chemical action in the food, no amount of materials and of heat avails for nutrition.

Plants live upon carbonic acid and ammonia; but, as stated by Müller, carbonate of ammonia, in every form, is a poison to them.

Secondly. The various kinds of food produce various forms of vital action, quite independently of the materials of which they consist. The food of all

animals scarcely varies in its elements. But in the nature and intensity of the chemical changes it undergoes, it presents innumerable and most important variations. And upon these, as one element, the characteristic differences of vital action in the various tribes of animals, doubtless, in part depend.

Nothing can more strikingly confirm this view than the difference of the vegetable structures which respectively accompany the vinous and acetous fermentations. Special modes of chemical action will alone maintain specific forms of life.

Thirdly. The vitalisation of the elements of the food is effected, not through the medium of its spontaneous decomposition, but by more energetic chemical changes wrought by the digestive fluids. The vital motion is conditional upon a decomposing motion intensified by contact with the products of secretion.

Parallel instances are not wanting. Muscles waste unless their decomposition be rendered more rapid by those influences which bring them into functional activity. Plants attain no vigour unless decomposition be hastened in their leaves by light. And the earliest changes in the embryo, "consisting in the formation of a membrane upon the exterior,

while a large part of the included substance undergoes liquefaction," indicate the operation of the same law. The phenomena of inflammation fall into the same category. Two things are evident in it:—first, an abnormal activity of the chemical or decomposing processes; and, secondly, an increased vital action consequent thereupon.

Into these two groups the events which constitute inflammation plainly resolve themselves. Its causes are ever such as either directly carry decomposition to an excess, or have practically the same effect by arresting vital action. Its tendency is primarily to disintegration, or the death of parts. It is in its beginning an increased chemical or antivital change.

In this derangement of the actions which constitute life consists that unseen change which precedes and causes the various physical and mechanical phenomena which observation recognises or the microscope reveals. And closely following this accelerated decomposition, comes, by the law of life, that increased vital action upon which a prevalent idea of inflammation has been based.

Thus the conception of chemical and vital action

as constituting a vibration is found to unfold particular phenomena of life. But it does more than this. It shows why in the actual life of the animal these two forms of action constitute an inseparable chain, and, when regarded as unconnected processes, an inextricable maze. That which should be on this supposition, is precisely that which is; vital action perpetually followed by chemical, and chemical again by vital. From first to last, that is the history of life.

The varieties of vital action also, the differences between specific kinds of life, find a satisfactory origin in the scarcely less numerous varieties of chemical action. The supposition of specific vital properties or tendencies falls by the abstraction of its foundation. The varieties of life are the varieties of chemical action presented under another aspect.

The elements, therefore, which are involved in this lowest idea of life are two—a chemical attraction or force, and a definite resistance to that force. From these two elements result chemical and vital action. But there is rightly speaking no vital force. The action of a pendulum involves the same ideas—a gravitating attraction or force, and a defi-

nite resistance; resulting in a gravitating and an ascending action. But there is in the pendulum no *"ascending force."*

II. This view of vital action is conformable to the general course of Nature. The entire succession of events, which we call the course of Nature, involves essentially the same elements as those which we have found in life, namely, an action and a resistance. A force, or form of action, resisted, assumes of necessity another direction or another form. This is the law, the results of which have been grouped under the denomination of the correlation or conversion of the forces. That motion takes the direction of least resistance, in one aspect of the case, embraces the whole. It is not difficult to trace the working of this law so far as our knowledge is exact and definite. It becomes obscure precisely where our ideas lose their distinctness.

Motion, if it be resisted, becomes heat or light, or some other force, but only on condition that it *be* resisted. Heat, if its transmission or continuance be resisted, assumes other forms; thus it passes freely through a homogeneous metal and undergoes no change, but if forcibly applied to a nonconductor, as glass, that is, to a body which resists

it, it is changed into motion, evidenced by the fracture of the glass; or at the point of junction of two metals, where its passage is resisted, it becomes electricity. Electricity again passes almost without change along a wire, until its quantity becomes too great for the wire to convey, when that which is resisted assumes the form of heat or light. The electric spark arises only at those points at which the passage of the current is resisted.

The production of electricity from chemical action may be traced to the same law.

If the flame of an ordinary taper be observed, a current of wax is seen rising towards the flame. There exists also another invisible current, viz. that of the air towards the same flame, but in the opposite direction. The atmosphere, however, being a compound body, this atmospheric current is necessarily double, the nitrogen being repelled from the flame as the oxygen approaches it.

Conceive now a flame supported by hydrogen on the one side and air upon the other. On the one hand the hydrogen being attracted to the point of chemical action constitutes a single current in that direction; the oxygen being also attracted, there arises in the air a double current, one towards and

one away from the flame. Now the hydrogen current towards the flame and the nitrogen current from the flame being on opposite sides are in the same direction; and it may be conceived, in theory at least, that by a mechanical arrangement of tubes these two currents might be united, so that the impulse of the current of nitrogen *from* the flame should serve to augment the momentum of the hydrogen current *towards* the flame, facilitating by so much its union with the oxygen.

In a zinc and platinum galvanic battery the process which takes place is the same—the element added is a resistance to the freely circulating currents we have been considering. For the particles of the zinc are attracted to the point of chemical union in the same way as those of hydrogen are attracted, but the cohesion of its structure resists their motion. Hence there is produced in it a tension, which, while on the one hand it represents the motion of its particles towards the acid, *resisted*, constitutes, on the other, the electric state.

But the dilute acid being a compound body, there exists in it, as before noted in the atmosphere, a double current; the oxygen moving towards, the hydrogen away from, the point of chemical union.

The impulse of the hydrogen being imparted to the particles of the platinum, and the motion resisted in the latter by its cohesion of structure, there is produced in it, as in the zinc plate, a state of electric tension, but in a direction way from the point of chemical action. These two tensions, therefore, are really in one direction: unite them by a conductor of that special form of motion, and what ensues but a current, adding the momentum of the tension of the platinum to that of the zinc, and facilitating by so much the union of the zinc with the oxygen?

This view of the production of galvanism by chemical action receives strong confirmation from the state of tension generated in portions of gold by hydrochloric and nitric acid, separated by a porous partition. From what cause can such tension arise but from the attraction of the chlorine resisted by the cohesion of the gold, and how can the completion of the circuit avail to determine chemical action, if it be not by overcoming that cohesion, through the union of the two momenta?

Other instances of the law that change of one form of action into another is caused by a resistance to the action so changed, I need not now

adduce. It is, indeed, sufficient to inquire to what else can such a change be referred? or to what else but to an incredible multiplication of specific properties, before which even the imagination stands aghast?

This, then, we find in Nature:—Motion assuming endless forms in accordance with an ever-varying resistance. But the resistance, though ever-varying, is one. To one force, indeed, there can be but one resistance: if force be single, although multiform, resistance, although multiform, must be single also.

Force being regarded as motion, all the modes and forms of resistance might be generalized under the idea of *cohesion;* the variety in it depending upon diversity of structure or arrangement.

If a ball strike against a wall, its motion, to a certain extent, ceases and is changed. But the resistance of the wall is no property of the matter of which it is composed; if the cohesion of the particles forming it be destroyed, it no longer resists or converts the motion. In the same matter, friction produces heat or electricity, according to most inconsiderable diversities of structure. Light is partially resisted and converted into heat, if the

surface of glass be roughened. All non-conductors or resisting bodies are such by virtue of their structure: not the elements, but the mode in which they are arranged determines their resisting power. A gaseous mixture of oxygen, hydrogen, nitrogen, and carbonic acid, resists the electric current, but the same elements united into a muscle conduct it readily.

The resistance to chemical action, which causes it to become vital action, might be termed *organic cohesion.*

A comparison of organic cohesion with the cohesion of inorganic bodies, which, by resistance, changes one form of force into another, elicits many points of resemblance.

For example, the change of the force depends upon a certain relation between the force and the resistance. An excess of force overcomes the cohesion, and destroys thereby the power of resistance. Too hard a blow breaks a solid body: an excess of electricity rends a non-conductor. So, too intense a chemical action destroys vitality. May not putrefying matters and some poisons act in this way?

Again: the resistance remaining the same, a given

motion produces entirely different results, according to its amount or intensity. Thus, if a bullet be projected against an open door with very little force, its motion is stopped, a certain amount of heat is generated, but the door remains unmoved; if it be fired from a pistol, it passes through the door, which still remains unmoved; but if it be projected with an intermediate degree of force, the door is moved upon its hinges. Much that is similar to this takes place in the living body.

The mere passive decay of a tissue designed for use produces no vital action; an unused muscle wastes; excessive or morbid decomposition may equally fail to be followed by the nutritive process, as when death ensues from prolonged over-exertion, or atrophy from inflammation. Only an intermediate intensity of chemical action, not varying much from that which attends the normal activity of the tissues, will maintain the vital process.

There are some facts which, upon a cursory view, might give the impression that the growth of living organisms is the cause rather than the effect of chemical action or decomposition. The production of fermentation by yeast is an example.

The true meaning of these facts appears at once upon a reference to the inorganic world.

The completion of the circuit in a galvanic battery may occasion, and always increases, the chemical action. When the uniting wire is small and becomes heated by the current, the chemical action takes place more freely in proportion to the readiness with which the heat of the wire can be dissipated. Or, more simply, if two weights be suspended over a pulley, the more easily the one is made to ascend, the more readily and rapidly will the other descend.

The presence of living matter facilitates decay, by affording a ready passage, as it were, to the resulting force. Life bears the same relation to decomposition that the galvanic current bears to the union of oxygen with zinc, or that the ascent of one weight bears to the descent of another. Living germs permit decay by taking up—absorbing, it might almost be said—the resulting force. They act the part of a good conductor around the heated wire. I may observe here an instance of beneficent adaptation. Decay being to so great an extent dependent upon the occurrence of vital action, the

source of life is husbanded and reserved for the purposes of life. If complete decomposition took place rapidly in the soil independently of the existence of vegetation, how sad a barrenness would overspread the earth. But God has ordained it otherwise, and the life-producing chemistry tarries at His bidding for the germ.

Motion takes the direction of least resistance. If the resistance be absolute this direction is at right angles to the line of the original motion. That this must be the case is obvious, the rectangular direction being the mean between the momentum of the motion and the resistance supposed. And it is so in fact. A current of air striking against a flat surface passes off at a right angle in all directions: a soft mass propelled against such a surface becomes flattened, that is, expands at right angles to the line of motion; and a solid body, under similar conditions, tends to the same result, as evidenced by the fracture it undergoes if the momentum be sufficient.

This law may perhaps be traced in the production of magnetism from electricity. For a wire, while it conducts, at the same time resists, the electric current, and the iron bar across which it passes pre-

sents to it (that is, to a certain proportion of it) a direction of less resistance, at the same time altering its form. But the resistance of the wire tends to turn the electric current at right angles, which is the direction it assumes when it becomes magnetism.

If the resistance be not absolute (that is, if the motion be only partially turned from its direction, or if, it being entirely turned, the original force continues in operation so that it is constantly renewed,) the direction assumed will lie between the original course and a line at right angles to it.

And if the force producing the motion and the resistance are both of continued operation, the resulting motion will be curvilinear. One illustration will suffice. A bubble rising rapidly through water passes upwards either in one or many curves, and frequently in a spiral, closely resembling the form of a corkscrew.

So, also, a ball of moderate specific gravity, sinking in water, falls, not in a straight line, but in one or many curves, diverging more or less in proportion to the difference of density between itself and the medium through which it sinks. The curve described by the falling body represents the com-

position of two motions—namely, a downward movement turned at right angles, and a continuous gravitating movement.

That the motion of a body gravitating through a resisting medium will be turned at right angles, becomes obvious, when it is considered that the portion of the medium between the gravitating body and the point of attraction, is the densest and most resisting portion, both from the influence of the attracting mass upon the medium itself and from the pressure of the gravitating body.

There is one simple application of these principles, which I mention on account of its value as an illustration of the conception of life.

The motions of the heavenly bodies having been treated as if occurring in a vacuum, it has become necessary to assume a special impulse at right angles to the gravitating motion of the planets. But if the planets be conceived as gravitating from any requisite distance through a plenum or resisting medium, their motion towards the sun, being turned at right angles, the centrifugal force is no longer a hypothesis, but a demonstrable result.

Or the facts may be regarded from another point

of view. Conceive a planet, at the aphelion, gravitating towards the sun, but under such a resistance that its motion assumes the actual curve of its orbit. Under these conditions it falls by virtue of its gravitation—not *to* the sun, but beyond it. When it reaches its perihelion, it will have attained a momentum of motion which would carry it through a precisely corresponding curve, in opposition now to gravity, to the aphelion again—the point from which it started. This is the motion of a pendulum starting from the zenith and returning to the zenith, but with its point of gravitation within, instead of external to, its circuit. But a planet thus oscillating around the sun, would have less than the actual velocity, and would be, at the aphelion, momentarily at rest.

Two elements have to be supplied to bring the hypothesis into accordance with the facts—first, the resistance which turns the gravitating motion into the elliptic form, and secondly, the velocity of the planet at the aphelion. Both of these are supplied by supposing the planet to have gravitated through a resisting medium from a greater distance. An ordinary kite raised above the earth by being drawn

through the resisting atmosphere, sufficiently illustrates the principle upon which the argument is based.[1]

It is obvious that this hypothesis embraces also the motions of the double stars. Two masses, gravitating towards each other through a plenum, diverge as they approach, and falling beyond each other, continue in a mutual revolution, which is in truth but a prolonged vibration.

This motion of the double stars is the idea of life enacted on a different scale. Atoms, or stars, "endowed with approximating tendencies, carried perpetually into divergent relations!"

Thus, not only in the motions of the pendulum, but in those also of the stars, we might find an analogue of the essential process in organic life—a chemical force, resisted, producing a chemical and a vital motion.

[1] This illustration is suffered to remain, for illustration's sake; but I am aware that astronomical authority denies that the velocity really possessed by the planets could be thus derived.

JAMES HINTON.

1822 Born at Reading, the third child of John Howard Hinton, M.A., minister of the Hosier Street Baptist Chapel at Reading, and Eliza Birt, his wife.

1836 At school at Harpenden.

1838 Became cashier at a wholesale draper's, 123, High Street, Whitechapel.

1840 Clerk in an Insurance Office in the City of London.

1842 Entered as a student at St. Bartholomew's Hospital.

1846 Voyage to China as surgeon of the passenger ship *City of Derry*.

1847 Qualified with distinction, having previously gained several medals.

In practice as an assistant at Newport, Essex.

Medical Officer in charge of negro emigrants from Sierra Leone to Jamaica, where he remained at Roslyn for a year to satisfy himself as to their treatment and welfare, also taking medical charge of the Marine Hospital, the Gaol, and the Poorhouse.

1850 Returned to London after visiting New Orleans, and entered into partnership with Mr. Fisher in Bartholomew Close, London.

Became engaged to Miss Margaret Haddon, with whom he had been in love for ten years.

1852 Marriage.

In practice by himself as a London Surgeon in Charter House Square and specialising in aural surgery.

1853 Birth of his son Howard.

1856 Began to write for publication, various papers on physiological and ethical subjects.

1858 Published a paper in the *Medico-Chirurgical Review* "On Physical Morphology, or the Law of Organic Forms," suggesting that organic growth takes place in the direction of least resistance, a generalisation afterwards embodied by Herbert Spencer in his *First Principles.*

1859 Published (at first anonymously) *Man and his Dwelling Place: An Essay towards the Interpretation of Nature.*

1860 Encouraged by the success of this book, abandoned practice for literature and settled in Tottenham.

1862 Published *Life in Nature,* previously issued serially, under the title of *Physiological Riddles,* in the *Cornhill* by Thackeray.

1863 Returned to practice in George Street, Hanover Square, and was appointed Aural Surgeon at Guy's Hospital, the post being specially created for him.

1866 Removed to 18, Savile Row, succeeding to the practice of the eminent aurist, Toynbee, and

thenceforth took the first rank in this branch of his profession.

Published *The Mystery of Pain: A Book for the Sorrowful*, written three or four years earlier; several editions have since appeared.

1868 Visited Germany and Austria to study condition of aural surgery.

1869 Commenced writing again, and largely devoted his evenings to setting down his thoughts.

Published a pamphlet on *Nursing as a Profession.*

Joined the Metaphysical Society at the request of Tennyson, and became a regular attendant at its meetings.

1870 At the beginning of this year his later moral doctrines first began to appear in his MSS.

In this year he began (and completed in 1874) the private printing in four large volumes of unrevised MSS. written some ten years earlier, the last portion of the fourth volume, on Art, being more recent. They were placed in the British Museum Library and elsewhere.

At the outbreak of the Franco-German War made a tour with his family through France and Spain and on to St. Michael's in the Azores, where he had purchased a property, Grena.

New and revised edition of *Man and his Dwelling Place.*

1871 Thoughts on *Health and Some of its Conditions*, previously printed in the *Cornhill.*

1873 Delivered the opening lecture of the Session at

Guy's Hospital Medical School on *The Place of the Physician*, published with other essays in the following year.

1874 Retired from practice and left Savile Row.

Published the *Questions of Aural Surgery* and *An Atlas of the Diseases of the Membrana Tympani*, the drawings of which were executed by Mrs. Hinton; these books embodied the outcome of his professional work.

Also in this year edited *Physiology for Practical Use*, by various writers, in two volumes.

1875 In South Wales investigating the causes of a great strike among the miners at Merthyr Tydvil.

Sailed in the autumn with his family to settle on his estate and grow oranges at St. Michael's.

Died in Hospital at St. Michael's on December 16 and buried in the churchyard of the English Church at Ponta Delgada.

1878 *Life and Letters of James Hinton*, edited by Ellice Hopkins, with an Introduction by Sir William Gull.

1879 *Chapters on the Art of Thinking and Other Essays*, edited by C. H. Hinton, with an Introduction by Shadworth Hodgson.

1881 *Philosophy and Religion*, being passages from early printed *Selections from Manuscripts*, edited by Caroline Haddon.

1884 *The Law-Breaker and the Coming of the Law*, edited by Mrs. Hinton from the later Manuscripts, with an Introduction by Havelock Ellis.

1822
1875
1853

I LOVE YOU

1886 *The Larger Life: Studies in Hinton's Ethics*, by Caroline Haddon, with some of Hinton's unpublished letters.

1918 *James Hinton: A Sketch*, setting forth for the first time Hinton's views on sexual morality, by Mrs. Havelock Ellis, with a Preface by Havelock Ellis.

within my breast ... will be again,

without my hair, my face, myself,

the very eyes, and ...

that must be common ... every heart,

Also to thee.

& Mr. Stanley has painted ...

1 Ò Mahomet! Rose! Fore

At last! Affa